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THE QUARTERLY BULLETIN

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents: (1) progress reports on long-term major research projects; (2) final reports on short-term projects and (3) short, timely articles of a popular nature that bring together information from various sources on subjects in which farmers are interested.

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PROTECTION OF CROPS FROM FROST DAMAGE THROUGH THE USE OF RADIANT ENERGY

By A. W. FARRALL,[1] W. H. SHELDON,[2] and CLARENCE HANSEN[3]

SECTION OF AGRICULTURAL ENGINEERING[4]

ONE OF THE principal hazards of the fruit and truck crops and vegetable industry is that of frost damage. In Michigan alone that damage amounts to from $10,000,000 to $20,000,000 annually. Equal or greater losses from frost damage are found in other states, notably California and Florida. This damage not only causes loss but results in great fluctuation in the agricultural income and at times causes severe shortages in various types of products. There is a great need for some economical and effective means of preventing this frost damage.

FROST CONTROL METHODS NOW IN USE

Many efforts have been made to solve this problem of frost control, the principal method being the use of smudge-pots, air circulation devices, and water spray.

In California and Florida extensive use has been made of oil-operated smudge-pots. Intensive study has been made of the smudge-pot for the last 35 years with some improvement resulting. However, the results are uncertain, and the initial cost, as well as the cost of operation, is excessive. Furthermore, smoke and carbon particles in the air have been a serious problem.

The air circulation method of frost prevention was tested in California by Moses and co-workers, and they reported some promising results obtained with a 100-horse-power motor-driven airplane propellor used to circulate the air over an orchard. This method, however, has not been found dependable enough to warrant any widespread adoption. Some Michigan fruit growers report benefits from air circulation when using a high-speed sprayer fan to circulate the air.

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[4]Acknowledgment is made of substantial help in design of apparatus, and in obtaining material in connection with this project, to the Detroit Board of Commerce, through their research committee. Special thanks is due Mr. Douglas Dow, of the Detroit Edison Company, for specific and detailed assistance in design and in furnishing materials for the electrically operated radiation test equipment.

ARTICLE 29-7

In connection with the air-circulation method, it has been found that often the cold air will stratify on a still night. The lower layer of air within 10 or 15 feet of the ground may be cold enough to cause damage whereas the air above is warm, perhaps as much as 15 degrees warmer at a height of 50 feet.

Tests made at Michigan State College in the fall of 1945 with a large air-circulation unit without heat and with heat, added at the rate of one million B.T.U. per hour per acre, indicated that this was not a dependable method of frost prevention.

Preliminary tests with a helicopter furnished by the Army Air Forces of Dayton, Ohio, were made in the fall of 1945 at Michigan State College to determine whether a helicopter could be used to cover large areas and stir the air. It was found that when the helicopter had a forward speed of about 10 miles per hour and an elevation of approximately 40 feet above the ground it would stir the air very effectively for approximately 150 feet on each side of its center line of travel. There is a good possibility that if the hazards of night flying close to the ground with a helicopter could be overcome this method would have some merit where large areas were to be protected and in instances where there was a warm layer of air within a few feet above the ground. The present cost of helicopters is another deterring factor.

Some farmers, notably cranberry growers of Oregon, have made rather extensive use of water spray frost prevention equipment, and several hundred acres of their crop are now protected by a water spray method. With this unit, it is necessary to pipe water under pressure to the area and spray the water in a fine mist over the crop. Reasonably satisfactory results have been obtained in many instances although the cost of installation is high, often amounting to $300 or $400 per acre. This system depends for its effect upon the heat energy liberating properties of water as it crystallizes into ice. Plants of some varieties may be coated with a layer of ice at 32° F. without injury, and it is necessary only to maintain a constant film of water on the plant to prevent frost damage. The weight of ice, however, may cause serious damage to some types of plants and trees.

A fourth method of frost prevention which has been suggested is the use of fog-producing machines such as were developed for the Army. There is no evidence at the present time that these machines are of any particular value for frost prevention.

REQUIREMENTS FOR FROST PREVENTION

From a practical viewpoint, the grower is concerned principally with protecting his crop from frosts late in the spring and early in the fall. At those times of the year, often there will be only one or two nights during which frost damage occurs. If this period can be successfully passed without damage, the growing season can be effectively lengthened by at least 2 weeks to a month. Usually frost damage is caused by a temperature not much below freezing. It should be pointed out that it is probably impracticable at the present time to consider protection of crops from frost when the temperature of the plant would be much below 23° F., although if the crops were sufficiently valuable it is entirely possible they could be protected against much lower temperatures with the new radiant method.

Two principal types of conditions cause frost damage. The first and the least troublesome is that of a large body of cold, sub-freezing air moving into the area. This happens very infrequently in most areas at the time of the year when frost protection is needed. It is, however, very difficult to combat. The second and most usual type of condition which causes frost damage is when the air temperature is down near the freezing point, and the wind is practically non-existent and the sky is clear. Under these conditions heat from the earth and from the plant is radiated to the near absolute zero temperature of outer spaces. Even though the normal air temperature is several degrees above freezing, the radiation to outer spaces is so great that the surface of the earth and the plant is cooled below 32° F. and frost is formed.

The rate of this heat radiation to the outer spaces has been measured by a number of investigators. Gardner, Bradford and Hooker in their book, "Fundamentals of Fruit Production," state also that the heat lost by radiation is approximately one calorie per minute per square centimeter of soil area. This amounts to approximately one million B.T.U. per acre per hour.

It is apparent that in order to prevent frost from forming, it will be necessary, in some manner, to add sufficient energy to the earth and to the plant to counteract this radiation loss. A logical solution would be to find some means of carrying this energy directly to the plant and to the soil, without using the air as a medium of heat transfer and without using tremendous amounts of energy to warm the air itself.

A method of preventing the radiation from the earth would also be effective. At the present time, however, there is no known method for large scale blocking of radiation on a clear night. This is because heat radiation penetrates any normal smoke or fog which man has been able to devise.

After due consideration it seemed logical that one possible way of adding energy to the plants and to the soil would be by an infrared heat radiating device. In order to test the principle, an infrared radiation apparatus as described below was built and tested at Michigan State College.

AN INFRARED ELECTRICALLY OPERATED RADIATION DEVICE FOR FROST PREVENTION

Figure 1 shows an electrically-operated infrared radiator, which was built and tested at Michigan State College in the spring of 1946. The objectives were to determine: (1) Whether infrared radiant energy could be used effectively to prevent frost, (2) the amount of energy required per square foot of surface area necessary for protection, (3) the cost of operation, and (4) the possibilities of distribution of the energy over a considerable area.

DESCRIPTION OF THE APPARATUS

The apparatus consists essentially of an aluminum reflector with specially treated surface of proper shape to distribute the energy over

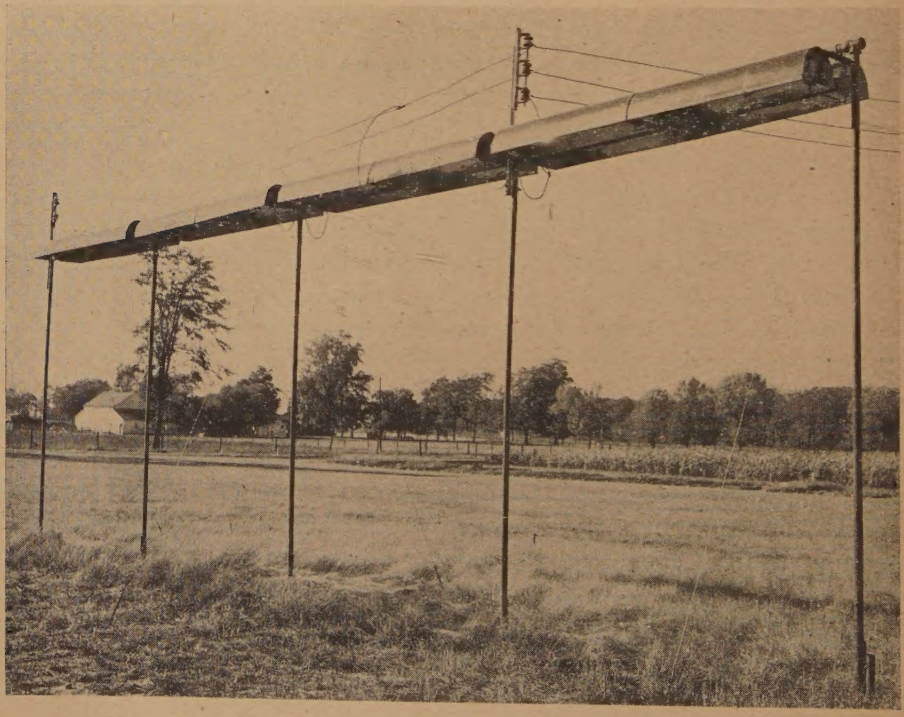

Fig. 1. Electrically operated radiation type frost prevention equipment.

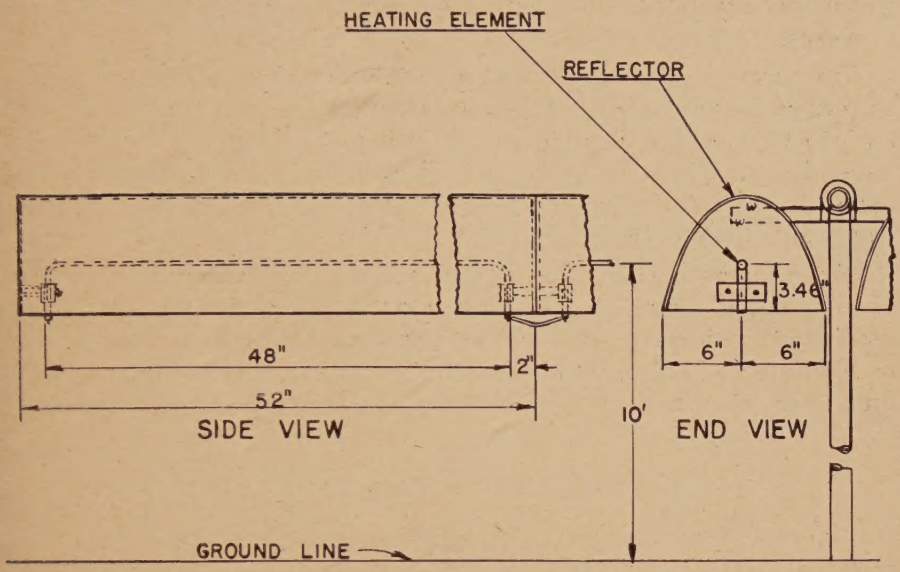

Fig. 2. Details showing the method of construction of electric radiation unit.

a given area, and a rod-type chromolox electric heating element so positioned as to focus the radiant energy over the prescribed area. The radiation unit was built up in sections and so positioned over the area to be protected that the prescribed area of 1,600 square feet could be covered. Fig. 2 shows the details of the heater units.

A double line of radiant units was used in order to minimize any inaccuracies in the reflector design or heating element radiation. Note also that on one end of the radiation assembly one of the heating units was omitted in order to give a portion of the area less radiation than the rest so that the effect of various radiation intensities could be more readily observed.

The unit was connected to a standard 3-phase 440-volt alternating current line.

METHOD OF CONDUCTING THE TEST

Tests were conducted on three different nights on which the United States Weather Bureau advised frost would occur. On each of these three nights there was frost of different degrees of intensity.

The frost prevention unit was turned on late in the evening and operated all night long. With the radiant heat striking the protected area 40 feet square half of which had bluegrass vegetation and half of

which was practically bare but with some occasional clumps of grass or weeds.

Temperatures were measured by means of chemical thermometers suspended above the ground, buried in vegetation near the ground, and buried in the soil at depths from 1 inch to 3 inches. Thermocouples were also used in some instances. In one set of tests the effect was noted on thermocouples attached to leaves of plants and to buds of transplanted apple trees.

Measurements were made of the uniformity of radiation by means of a radiation meter of the multiplethermopile type, the area being marked off with stakes at 5-foot intervals level with the ground so that an accurate and orderly survey of the radiation could be made. Readings were taken both in the protected area and just beyond the edge.

RESULTS OF THE TEST

Figure 3 shows the pattern of radiation intensity as measured by the radiation meter. It will be noted that there was a considerable variation in the intensity of the radiation probably owing to inaccuracies in the

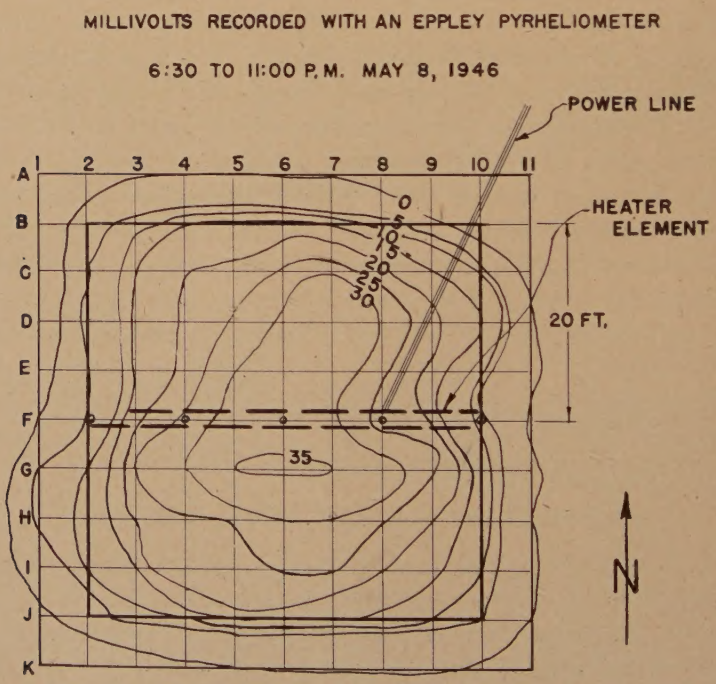

Fig. 3. Chart showing uniformity of distribution of radiant energy over the test area when using an electric radiation unit.

TABLE 1—*Summarization of the temperatures of the air, vegetation and ground within and outside the test area on three different days when the electrically operated radiation units were used.*

Date of test.....	May 8, 1946				May 12, 1946				May 13, 1946			
	Radiant heat		No heat		Radiant heat		No heat		Radiant heat		No heat	
	Grass	Bare	Grass	Bare	Grass	Bare	Grass	Bare	Grass	Bare	Grass	Bare
Temp. of air in °F.	34.0		33.5		31.0		30.5		27.5	32	26.5	
Temp. of grass in °F.	37.0		31.0		34		28		32	33.6	23.5	
Temp. of ground 1 inch deep in °F.	43.6	44.7	42.5	39	44		40		44	42	42.5	37
Temp. of ground 3 inches deep in °F.	43.0	43.9	44.0	41.5	47		44		43	44		42
Minimum pyroheliometer reading to prevent all frost.	10				20				20			

manufacture of the reflector or to the heating element being slightly out of position.

Table 1 shows the various temperatures and conditions observed at the end of each of the three night tests.

Figure 4 shows the detailed observations of frost conditions at end of one test.

It is of note that in every instance, even on the coldest nights, there was effective frost prevention. It was noted that in the tests of May 8 and 12 the vegetation was 6 degrees warmer inside the protected area than in the unprotected area; also that the temperature of the air in each case was only one-half degree warmer in the protected area as compared with the unprotected area. Note also that on May 13, 1946, the temperature of the vegetation outside of the protected area was 23.5° F. and was just at 32° F. inside the protected area, making a difference of 8½ degrees temperature rise for the vegetation. Note that in this test the temperature of the air outside the protected area was 26.5° F. and the temperatures were all as of 6:30 a.m., at which time they were at approximately the minimum. This indicated clearly that the energy was going into the grass and soil rather than being absorbed by the air.

All frost was prevented in the areas of the protected area where the radiation meter indicated an intensity of 20, even on the coldest nights.

Calculation of intensities and energy consumption by the unit indicated that a radiation equivalent to 10 watts per square foot is suf-

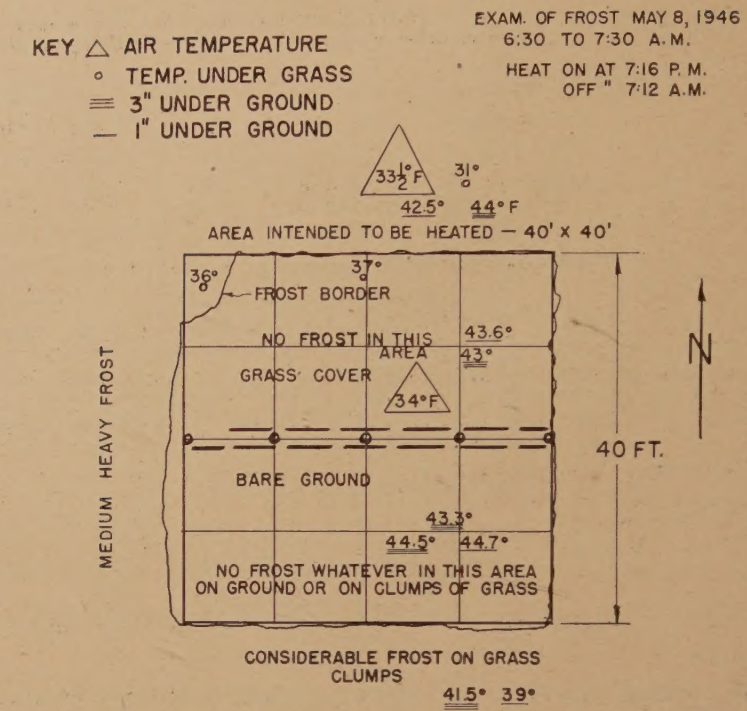

Fig. 4. Chart showing the detailed temperatures of air, vegetation and ground, together with the location of frost border at end of test when using the electrically operated radiant heater.

ficient to prevent radiation frost on vegetation of both thin and broad-leaf plants under the conditions of the test, which are considered to be approximately the normal requirements for late spring and early fall conditions.

A test setup of 250-watt standard infrared heat lamps was made and tested, and a preliminary field test made in the fall of 1946. These units are not well adapted to frost prevention use because of their particular pattern of energy distribution and also due to their fragile nature. They may possibly have value, however, in connection with extreme high value crops where low cost of operation is not an item to be considered.

OIL-HEATED TYPE RADIATION APPARATUS

The cost of electrical energy in most parts of the country, and the lack of transformer make the use of electrically operated anti-frost radiation equipment impracticable in all except those installations where low cost is not an important item and it was therefore determined to build and test an oil-heated radiation unit. It was determined that this

Fig. 5. Oil-heated type experimental frost prevention unit built and tested at Michigan State College. Note that this unit was built with a much more elaborate type of construction than would be required for regular agricultural use. The mounting of the unit on wheels, together with the various provisions for tipping the radiation unit into a horizontal position for travel on the highways, was necessary in order to facilitate transportation of the test unit to various fields. Various controls and measuring devices are also shown which were for experimental purposes only, and would not be needed for a standard agricultural unit. The fuel tanks consisted of a group of three 30-gallon hot water tanks. These could be replaced by ordinary oil drums. A satisfactory design could be mounted very inexpensively on skids.

The shape of the above-described unit is not the most efficient or least expensive for a final design. Such a shape was decided upon in order to test various elements of design and because the needed materials were available.

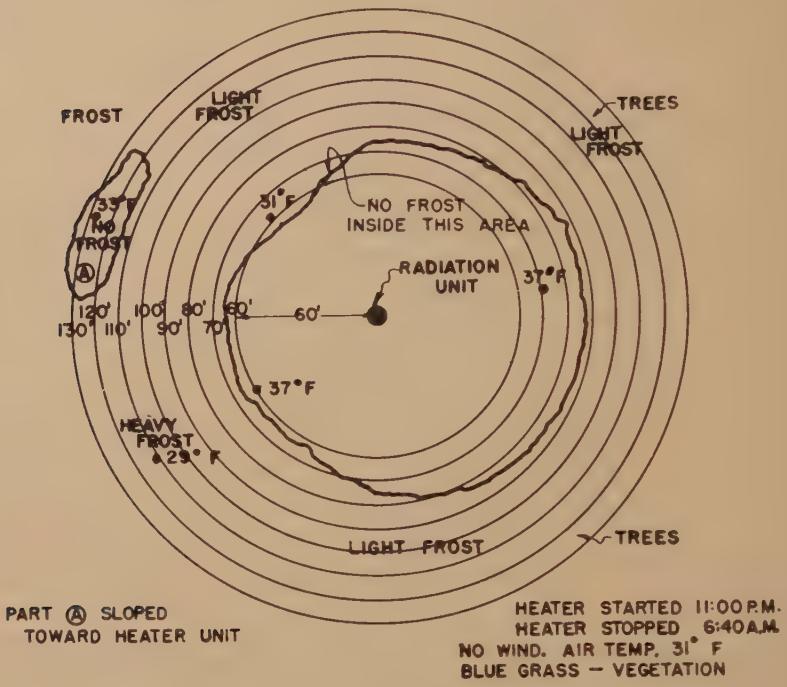

Fig. 6. Diagram showing the frost pattern and temperature of vegetation around the oil-heated frost protection unit on the morning of October 1, 1946. No frost was found on vegetation which was directly subject to the heat rays up to a distance of from 60 to 100 feet from the radiation unit.

oil-heated unit should, if possible, have capacity to protect approximately one acre of ground.

Figure 5 shows a design of an oil-heated radiation device which was built at Michigan State College and is now being tested. This device is essentially an oil burner with a heater tube which operates at low red heat, and a series of special type reflectors which direct the radiant heat down against the crop.

Figure 6 shows a diagram of the frost pattern on the vegetation surrounding the oil-heated unit after a test operation from 11 p.m. to 6:40 a.m. on the night of October 1, 1946. The frost was not extremely heavy on this night but was sufficient to indicate the pattern of frost protection. The irregularity of temperatures observed is likely due to inaccuracy in the shape of the reflectors on the unit and to the effect of nearby trees.

It was found that an excessive amount of energy was being directed close to the unit, owing to a defect of design and construction. When this is corrected, the area protected will be materially extended. The

unit consumed 50 gallons of kerosene during the test period of 7.6 hours and radiated approximately 672,000 B.T.U. per hour, assuming normal heater efficiency.

This and other tests indicate that the oil-heated radiation type heater offers a good possibility of being a practical and economical frost prevention unit.

Cost estimates on a practical oil-heated unit of the capacity described cannot be given accurately. The test unit, however, cost approximately $250.00. It is believed that a simple agricultural unit could be built for ⅓ to ½ this amount. Fuel oil costs should not exceed 75c per hour per acre for a unit liberating 1,000,000 B.T.U. per hour, which is estimated as adequate protection under most conditions.

PROTECTION FROM FREEZING INJURY BY RADIANT HEAT

The tests here reported deal exclusively with protection against frost on typical frosty radiation nights. Much of the injury from low temperature, however, is caused not by frost but by freezing of tissues. This occurs sometimes in the fall and spring, and often in mid-winter when no frost collects but perhaps there may be considerable wind. These are the conditions that have accompanied the most serious losses to citrus crops in the Gulf states and California, and to the peach crop in the northern states. Often a single night some season when killing temperatures occur for only a few hours, sometimes for only a few minutes, has been responsible for serious crop losses. The device here described has not been tested under such conditions—conditions under which the ordinary types of frost protection heretofore used are ineffective. It is suggested, however, that radiant heat should afford almost as effective protection under such conditions as during typical frosty radiation nights.

Note: Patent has been applied for by Michigan State College on this method and apparatus for frost protection.

CONDITIONING POPCORN TO THE PROPER MOISTURE CONTENT FOR BEST POPPING

By S. T. DEXTER
SECTION OF FARM CROPS

FOR THE BEST popping, popcorn should contain about 13.5 percent moisture, by weight. Corn that is too dry or too wet pops poorly. When stored in the open air, popcorn commonly dries out until it will give far less than maximum popping volume. On the other hand, if it is stored for a few days in very damp air, it becomes too damp to pop well and may even mold and spoil.

To describe the degree of dampness of the air, the term "relative humidity" is commonly used. This is simply the percentage of moisture in the air as compared with completely damp or "saturated" air. Air saturated with water vapor, that is, with a relative humidity of 100 percent would be found in a closed vessel partly filled with pure water. Air with a relative humidity of 50 percent would contain one-half as much moisture per cubic foot as air with a relative humidity of 100 percent.

Most common materials contain a certain amount of water, depending upon the relative humidity of the surrounding air. Thus, in air with a relative humidity of 50 percent cigars may be rather dry and brittle, and soda crackers rather damp and tough.

For popcorn to come to or stay at a moisture content of about 13.5 percent, the relative humidity must be approximately 75 percent. If wet corn is stored at that relative humidity, it will dry down to 13.5 percent, but no drier; and if dry corn, it will become more moist, until it reaches that figure, but will get no wetter.

In ordinary practice, the processors of popcorn pack the corn at about the proper moisture content and, by the use of relatively tight containers, attempt to keep the corn from drying out excessively before it reaches the user. Metal, lacquered cardboard, and cellophane containers of various sorts are commonly used.

ARTICLE 29-8

HOW TO OBTAIN A RELATIVE HUMIDITY OF 75 PERCENT

If any solid is dissolved in water, the tendency of the water to evaporate is decreased. If a closed vessel were partly filled with such a solution, the air in the vessel would have a relative humidity of less than 100 percent. By selecting the proper solution and the proper concentration, any desired relative humidity may be obtained.

Without further discussion of the principles involved, it may be stated that a saturated solution of common table salt (sodium chloride) gives a relative humidity of approximately 75 percent over a considerable range of temperature. The relative (and unusual) constancy of this figure is dependent upon the slight change in solubility of this substance at different temperatures.

PROCEDURE

Saturated salt solution is prepared by dissolving as much salt as possible in water. Warming and stirring speed up the process. There should always be an excess of salt left undissolved in the bottom of the dish. The salt solution may be absorbed by blotters, corn cobs, porous tiles or other absorbent materials. These are placed in a reasonably tight container with the corn. If the air is drier than a relative humidity of 75 percent, the water in the solution evaporates; but the dry corn takes up the moisture until both corn and solution finally have an equal tendency to give up water. When this equilibrium is reached, the corn has the proper moisture content. For equilibrium to be obtained *quickly*, however, the atmosphere should be uniformly at 75 percent relative humidity. Since moisture moves readily a distance of only a few inches through corn, it is best to have a good distribution of the solution-containing absorbents in the corn.

HOW MUCH SOLUTION TO USE

It might be feared that corn in contact with such a moistened body might mold. This is not the case—nor does the corn become too damp if large excesses of solution are used. Since nothing is lost from the solution except water, and the salt remains to be used again, there is little object in trying to economize with the solution, but rather one should be sure that sufficient solution is present. One or two specific cases can illustrate the point. Suppose that the corn is extremely dry, at a moisture content of about 8.5 percent and that it will go to a moisture content of 13.5 percent. Moisture to the extent of 5 percent of the weight of the corn would be taken up. Since the solution is about one-third salt, solution to the extent of about 7 percent of the weight

of the corn would furnish this water and would provide a small excess that would do no harm. For a pound of very dry corn, then, approximately an ounce of solution would be sufficient. Suppose in the second case that the corn is at 12-percent moisture content. To recondition 100 pounds would require 1.5 pounds of water, and about 2 pounds of solution absorbed on corn cobs or other absorbent and distributed through the corn.

ABSORBENT REQUIRED TO HOLD A POUND OF WATER

A pound of dry corn cobs was found to take up approximately 2.5 pounds of water when soaked in brine. Sixty percent of the volume occupied by the corn cobs was found to be water. Thus, if one cubic foot of storage space is occupied by soaked cobs, approximately 35 pounds of water would be added. With other lots of cobs or other absorbents the values would be somewhat different.

TIME REQUIRED TO RECONDITION CORN

Obviously, the rapidity with which equilibrium is attained will depend upon the dryness of the corn, the size and distribution of the evaporating and absorbing surfaces, and the movement of the air in the container. With ordinary corn, not excessively dried out, and with good distribution of the solution through the corn, proper moisture content should be reached in 1 to 3 days. Further storage up to 10 days is likely to be slightly beneficial, with little change beyond that time. A slight circulation of air would speed up the process since moisture moves but slowly in a mass of corn. Later in this paper specific figures are given for various lots of corn, where the solution was placed either above or below the corn.

TYPES OF DRY CORN

During the spring months of 1945, many lots of popcorn were reconditioned. Some had been stored in the laboratory as long as 10 years. Other lots were no more than a year old. Some had been stored near steam radiators, and others in a barn. White hulless, giant yellows, small yellows, bantam yellow, white rice, and hybrid varieties were used. Some lots were small, one lot exceeded 100 pounds, and was reconditioned in a large garbage can. No definite differences between the lots could be distinguished, on a variety basis.

SPECIFIC CASES OF RECONDITIONING DRY CORN

(1) A sample of white hulless, stored in the laboratory for about 10 years contained about 9 percent moisture. About 5 pounds of this corn reconditioned in a large bottle had a moisture content of 13.0 per-

cent at the end of two weeks. Two weeks later it had a moisture content of 13.7 percent and a popping volume 26 times the volume of the dry corn, with 98 percent of the corn popping. At the time of writing this article, 18 months later, this corn was still in storage with the solution and in excellent popping condition.

(2) White hulless, stored in a cool barn, had a moisture content of about 10.5 percent. Four pounds reached a moisture content of 13.6 percent in 10 days.

(3) Small yellow corn. On April 18, 10.6 percent moisture; April 25, 12.5 percent; April 30, 13.4 percent.

(4) White hulless. April 28, 8.9 percent moisture; May 5, 13.8 percent. This was a small sample.

(5) A sample of about 30 pounds of giant yellow corn. May 7, 9.9 percent moisture; May 26, 13.7 percent. Popping volume 27.5 times volume of dry corn.

COMMERCIAL SAMPLES OF CORN

These samples were obtained from the sacking machine and from the shipping platform of a major processing plant. All seemed to pop excellently, but were improved by treatment.

(1) Best grade white hulless, but said to be a "little off". Popping volume was improved 10 percent by treatment; the amount of unpopped kernels decreased 20 percent.

(2) Dwarf yellow hulless, as sold to customers at their retail counter. Popping volume increased over 50 percent by treatment; unpopped kernels decreased to one-third the former amount.

(3) South American yellow, best quality, popping volume increased 12 percent; unpopped kernels decreased 25 percent.

(4) Sunburst, popping volume increased 31 percent.

SAMPLES STORED ON THE EAR

(1) Hulless, found thrown to horses in a farmers barn. Considered not capable of being popped, following years of storage in attic. Full popping ability restored.

(2) Hybrid hulless, stored too long. A 15-percent increase in volume achieved. Other samples purchased on the open market were found to be improved by reconditioning.

HOW DRY THE CORN CAN BE

Popcorn of fair quality was brought to a moisture content of 13.5 percent. Twenty-gram samples of this corn were then exposed to the temperatures of 95°, 104°, 122°, and 147° F. with forced ventilation for 1, 2 and 3 hours. The samples were then placed in test tubes, with blotters soaked in saturated salt solution. The samples were weighed at intervals to determine how rapidly the water was again taken up. Table 1 shows the results, including popping volumes and unpopped kernels.

Since the above treatment seemed to do but little damage, the experiment was repeated, but with more extensive drying. Table 2 shows the results of this experiment.

From the results reported in these two tables, it would appear that heating popcorn to 147° F. and a moisture content of 6 percent does not destroy the popping characteristics of corn, once it has been properly dried.

EFFECTS OF RAPID INITIAL DRYING AT A HIGH TEMPERATURE

Popcorn was taken from a bin after a week or two of drying following harvest. Much of the corn was high in moisture. It was dried in a forced draft at about 150° F. Although it had good popping char-

TABLE 1—*A 20-gram sample of corn, containing about 230 kernels, and with a volume of 23 cc. was heated at the temperatures and for the time shown. The weights following heating and after periods of exposure with saturated salt solution are shown, together with the volume of the popped corn and the number of unpopped kernels.*

	After heating	After treatment		Volume	Unpopped kernels
	July 28	Aug. 11	Sept. 15		
	gr.	gr.	gr.	cc.	number
95° F.					
1 hour	19.70	19.98	20.00	550	5
2 hours	19.59	19.94	20.11	560	10
3 hours	19.54	19.93	19.94	520	6
104° F.					
1 hour	19.61	19.92	19.97	540	4
2 hours	19.48	19.91	19.96	550	3
3 hours	19.41	19.88	20.00	490	12
122° F.					
1 hour	19.50	19.90	19.97	560	6
2 hours	19.32	19.87	20.02	510	13
3 hours	19.18	19.98	19.99	540	6
147° F.					
1 hour	19.27	19.93	19.96	520	6
2 hours	19.11	19.80	19.95	495	6
3 hours	18.86	19.68	19.88	475	15

TABLE 2—*On Sept. 17, 1945, 20-gram samples were heated as shown and then stored with saturated salt solution until May 22, 1946. At the start, the samples contained 13.5 percent moisture.*

	Sept. 17	May 22	Moisture after drying	Popping volume	Unpopped kernels
	gr.	gr.	percent	cc.	number
122° F.					
113 hours	18.51*	18.54*	6.7*	*	*
113 hours	18.51	19.96	6.7	520	11
147° F.					
15 hours	19.40	19.88	6.0	550	14
15 hours	18.33	19.91	5.6	515	12
Unheated, but with solution	20.00	20.06	.....	530	11

*Sample stored without salt solution. No satisfactory popping.

acteristics when dried fully in the bin, its popping volume was seriously decreased by the rapid drying at this high temperature. Treatment of this corn with saturated salt solution has never restored the popping quality completely, and the corn remains unsatisfactory for use.

Further experiments are planned in which the limitations of the original drying process can be explored.

SUMMARY

Popcorn that has been grown and dried in such a manner that it has once possessed good popping quality may be restored to good popping quality in case it becomes too dry. Storage of the corn in an atmosphere of approximately 75 percent relative humidity will bring the moisture content up to the desired figure. A saturated solution of table salt, absorbed by blotters, corn cobs or other material, may be placed in a closed container with the corn. This solution provides the proper relative humidity. Corn has been stored in such containers for more than a year with no damage to the corn and with the popping quality unimpaired. No sample of corn was discovered, no matter how old, that could not be restored to good popping quality, provided that it had not been injured in the initial drying.

(Application has been made for a patent covering certain applications of the principle here explained.)

EQUALIZING EDUCATIONAL OPPORTUNITIES FOR RURAL CHILDREN IN MISSAUKEE COUNTY

By J. F. THADEN, C. L. TAYLOR,[1] and FORD FINKEL[2]
SECTION OF SOCIOLOGY AND ANTHROPOLOGY

THE RURAL SCHOOL problem of Michigan is now the most important school problem of the state. The rural resident's problem of providing his children with an education, both elementary and secondary, as adequate as that available to most urban children, has been largely solved in three-fourths of Missaukee County through cooperation, by the merging of 54 school districts into five rural agricultural school districts. Missaukee County had 69 school districts in 1922, which had been reduced to 18 by September 1946. This is a reduction of 74 percent, a greater reduction than in any other county during that same period, except adjacent Roscommon with a very much more sparse population.

The local equalization movement began in 1923 when educational-minded local leaders and the farm families in the northeastern part of the county, in the seven school districts in Norwich Township, each with a one-room school, voted to merge. The result was a township rural agricultural district with one school board, and after some years a central two-room elementary school at Moorestown. This was followed in 1930 by the farmers in six school districts in four different townships in the eastern section of the county forming the Merritt Rural Agricultural School District. In 1936, the farmers of two districts united with the farmers and villagers in the Falmouth School District in south-central Missaukee to create the Falmouth Rural Agricultural School. In 1944, 10 school districts in the western part of the county united to form the Lake City Rural Agricultural School. Lastly, in 1945, the farmers and townsmen in and around McBain created the McBain Rural Agricultural School out of their 13 separate districts in the southern area of the county.

Since the original formation of the five rural agricultural school districts, farmers in 12 other districts chose to annex to one or another

[1]Mr. Taylor was the Missaukee County School Commissioner from 1931 to 1937 and previous to that was a teacher in the county.

[2]Mr. Finkel has been School Commissioner of Missaukee County since 1937. Before that he was a teacher in the county.

of those five districts, although their children would have fared much better through the years if they had been parts of the original enlarged taxing and administrative units. Six districts, three of which are now within the five rural agricultural districts, disbanded earlier. Thus, five rural agricultural school districts now comprise what formerly were 54 separate districts. Three other districts were also abandoned earlier and were absorbed by one or another of the remaining primary districts. The story of the reduction of 70 school districts in Missaukee County in 1919 into the present 18 districts, and the conversion of 54 school districts into 5 rural agricultural school districts, is a story that could happen anywhere, and many residents are wondering why it has not taken place. Others wonder why these rural agricultural school districts were so slow in being created, why the reorganizations around Lake City and McBain did not occur two decades or more ago as in about 50 other communities of the state, and why the reorganizations were not completed—that is, the districts reorganized to the extent that every child would reside in his own 12-grade school district and each such district coincide with the composite trade and service areas of the village or city within which the high school is located.

MISSAUKEE, A RURAL COUNTY

Rural areas are reputed to be conservative in their efforts to equalize educational inequalities; yet, Missaukee County is one of the state's 22 counties that is 100 percent rural; that is, it has no incorporated city or village of 2,500 or more inhabitants. In fact, the largest place is the county seat, Lake City, with 693 inhabitants, while the only other incorporated place, also incorporated as a city, is McBain with 489 inhabitants. Both places lost population, as did the rest of the county, since the hey-day of Paul Bunyan. Both cities apparently reached their zenith in 1900 when Lake City had 816 inhabitants and McBain 709. Falmouth has 57 families and each of the 16 other hamlets and cross-road centers has a considerably smaller number of persons and families. Of its total rural population, 74 percent are farmers, a higher proportion than in any other county of the state. It is a county with many Hollanders, especially in the southern part, largely of the Christian Reformed faith, who operate four elementary parochial schools with 243 pupils, one in adjacent Highland Township of Osceola County, and a high school in McBain with 83 pupils. Of greatest significance is the fact that Missaukee has seemingly equalized educational opportunities for its children to a greater extent than any other county with equal or greater farm population density per square mile. However, reorganization is still incomplete, since 18 taxing and administrative units pre-

vail where there should be only two, exclusive of the area served by Manton in adjacent Wexford County. Of the five reorganizations, McBain, the center of a large settlement of Hollanders, was the last to reorganize.

THE HOLLAND SETTLEMENT

In southern Missaukee County, contiguous with northeastern Osceola County, is the second largest Holland settlement in the state. This conservative ethnic element, except for some of its educational leaders, tends to exert a restraining influence on the trend to equalize educational opportunities locally. It is significant that the Hollanders are centered largely in the townships of Riverside, Richland, and Clam Union in each of which the average price of land in 1940 was $29 per acre. The price of land in the other 12 townships of Missaukee County averaged $19 per acre. The best farm land, where sugar beets and string beans are primarily grown, is predominantly operated by the Dutch. Local wealth frequently tends to check the equalization of educational opportunities.

According to the United States Religious Census of 1936, three-fourths of the church members in Missaukee County belonged to either the Reformed or Christian Reformed Church, a larger percentage than in any other county. Sixty-three percent of the church members were members of the Christian Reformed Church. Members of the Reformed Church in America comprise 12 percent of all church members in Missaukee. Both percentages are higher than in most other counties. Three Reformed churches are located in the southern part of the county. With the exception of a small church midway between Lake City and Manton, all eight of the Christian Reformed churches are located in the southern part of Missaukee County and in adjacent Highland Township, Osceola County.

Christian Reformists are strong believers in "Christian" education for their children. For that reason they operate the five parochial schools already mentioned. Two parochial school buses drive some 40 miles twice daily to transport youngsters from Christian Reformed homes to the Northern Michigan Christian High in McBain and cover much of the same territory traveled by the 10 public school buses from McBain and Falmouth. "Northern" is not an accredited school, so its graduates are not eligible for admission to the state colleges and universities without entrance examinations.

Christian Reformed families are large, 26 percent larger than other

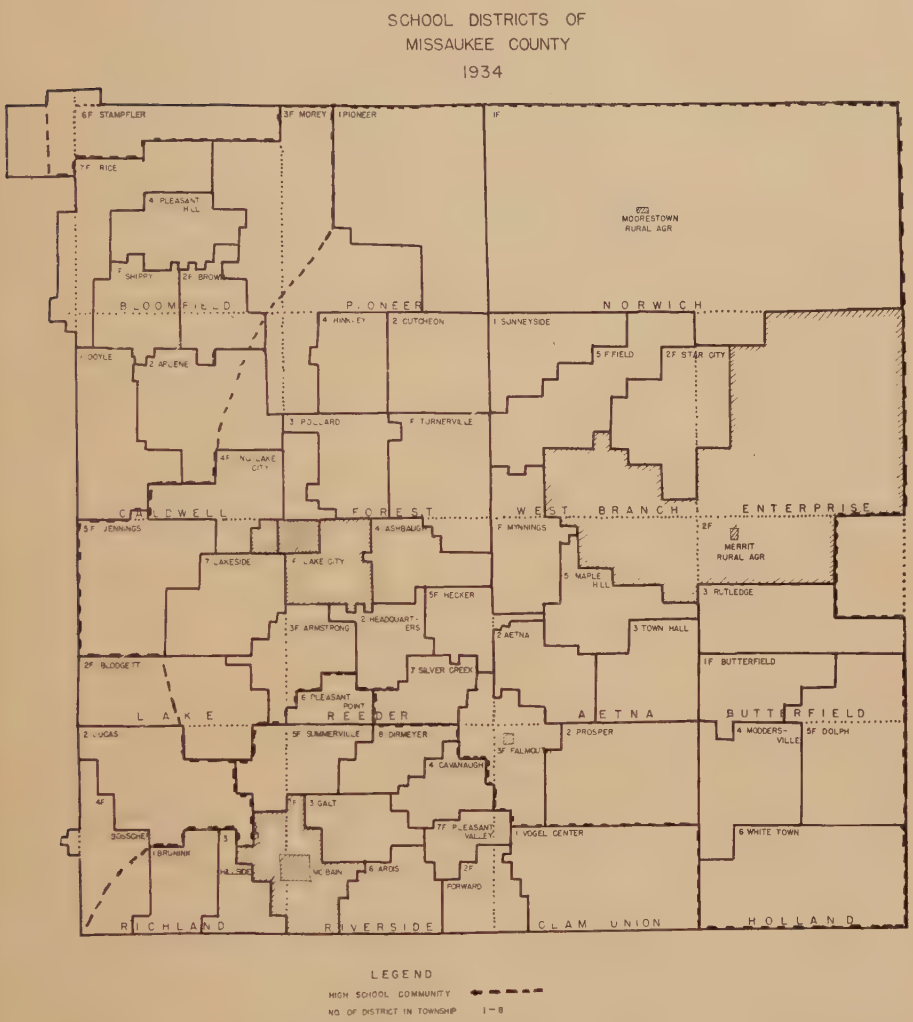

Fig. 1. School districts of Missaukee County, 1934.

families of Missaukee County. A total of 473 families are members of the seven Christian Reformed churches within Missaukee County. These families total 2,270 persons, or an average of 4.8 persons per family. Non-Christian Reformed families average 3.8 persons. It is this population element that is contributing primarily to the natural growth of the county. Birth rate in this county was 25.6 during the period 1935-45, one of the highest in the state. The high birth rate is reflected in its youthful population. In 1940, 32.8 percent of the population of Missaukee was of school age, 5 to 19 years, higher than in any other

county, except Presque Isle, which has many Germans and Poles. In reproduction, southern Missaukee is a "little bit of Holland" transplanted. A large number of children, in terms of financial resources, reinforces the need for equalization of educational funds.

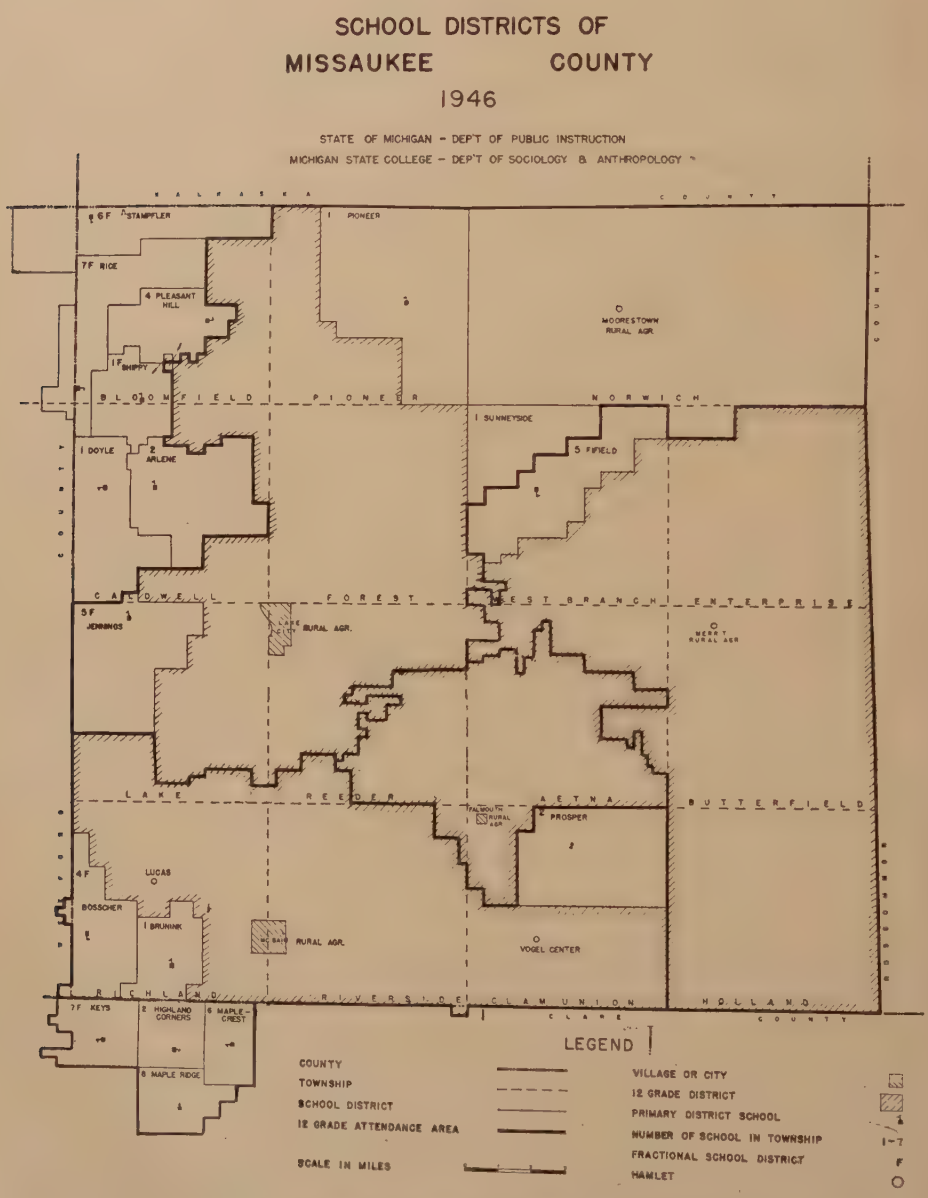

Fig. 2. School districts of Missaukee County, and part of Highland Township, Osceola County, September 1946.

SCHOOL DISTRICTS IN 1934 COMPARED WITH 1946

School districts of Missaukee County, as they were in 1934, when 53 were still functioning, appear in Fig. 1. From it some conception of their variation in size and shape is evident, as diversified as women's hats. In size, they varied from 3 to 73 square miles. In shape, they range from a perfect square to a much gerrymandered voting precinct. Valuation per census child was from $726 to $3,576.

Figure 2 indicates the layout of school districts in Missaukee County on September 1, 1946, when 18 districts remained. It also shows the four districts in the county to the south, which are served by the McBain school. Three-fourths of Missaukee County now lies within the five rural agricultural districts. Their approximate areas in square miles are as follows: Falmouth, 50; McBain, 90; Lake City, 110; Merritt, 135; and Norwich, 73. These areas are 6 to 16 times the size of the average of the 70 districts in 1919, which was 8 square miles. The reorganizations were slow in development, partly because the county is entirely rural where acceptance of social inventions tend to proceed cautiously. This was further retarded by a characteristically conservative element in the population.

CAUSES FOR REORGANIZATION

The factors restraining reorganization were somewhat counterbalanced by numerous favorable elements. The trend toward equalization of educational opportunities among rural families in Missaukee County, as in many other areas, has been induced and accelerated by many factors. These include declining population, shrinking size of families, exodus to cities, difficulty of finding well-qualified teachers, closing or partial closing of schools, sense of satisfaction attending these closings and the transportation of their children to graded districts, improved roads and snow removal facilitating transportation for all families, increasing proportion of eighth grade youngsters going to high school, desire for a well-rounded curriculum, reorganization tendencies in adjoining counties, increasing proportion of the cost of education borne by the state, far-sighted local educational leaders, and the stimulus of the findings and recommendations of the Michigan Public Education Study Commission.

REORGANIZATION IN ADJACENT COUNTIES

Missaukee County is surrounded on all sides by numerous school district reorganizations. The advantage of their enlarged taxing and administrative units are obvious to anyone who makes thorough studies of them. To the west is the Manton Rural Agricultural District which

dates from 1922. Marion Rural Agricultural District lies to the south. Also to the south is the Summerfield Township School District, which is affiliated with the Harrison Rural Agricultural School. Fife Lake Township District and Kingsley Township Rural Agricultural District border on the northwest. Joining Missaukee to the east is the Roscommon Township District. Virtually adjoining Missaukee County to the northeast is the Gerrish-Higgins Rural Agricultural District centered at Roscommon. These reorganized districts were formed since 1930 and range in area from 34 to 155 square miles. These reorganizations have stimulated many people in Missaukee County to provide similar educational opportunities for their children.

POPULATION CHANGES

The Federal Census indicates that Missaukee County attained its peak population in 1910 when it reached 10,606. It dropped to 9,004 in 1920, to 6,992 in 1930, and then partially recouped its former losses during the decade 1930-39 by attaining 8,034 at the time of the 1940 census. It was between 1900 and 1910, soon after the peak of the lumber industry, that the cities of McBain and Lake City, and all townships, except Butterfield, reached their maximum population. The Agricultural Census of 1945 gives evidence that the population of the county has slipped below that of 1930. The census of 1940 lists 1,214 farms in the county, while the census of 1945 lists only 1,005, a decrease of 18 percent. Diminishing population induces enlargement of school districts, frequently a case of economic necessity.

In 1930, Missaukee County was one of 57 counties in the state with a smaller population than formerly. Only nine counties, all more northerly, had suffered a greater loss in population from date of maximum population to 1930.[1]

MIGRATION FROM COUNTY 1935-45

In 1935, the estimated population of Missaukee County, based on the school census, was 8,373. It dropped steadily since then and reached a low level of 6,854 in 1945, a decrease of 1,519. During the same 11-year period, births totaled 2,059 and deaths 926, resulting in a natural increase of 1,133. Thus, despite a considerable excess of births over deaths, the county declined in population due to migration, amounting to 2,652. Apparently Missaukee County's principal crop is not so much that of string beans, hay, potatoes, sugar beets, and dairy products as it is babies—human resources rather than material and natural re-

[1] J. F. Thaden, *Population Trends in Michigan*, Special Bulletin 236, Michigan Agricultural Experiment Station, 1933, p. 25.

sources. Yearly, Missaukee County brings to maturity more than 100 persons on whom it has spent many thousands of dollars in the form of food, clothing, shelter, maintenance of health, and education, who migrate to the larger cities at the prime of their income-earning years. The state has increasingly felt a responsibility for the education of its children regardless of residence and mobility. Continued high birth and natural increase rates may be expected in Missaukee County and a correspondingly high loss through migration during prosperous years. However, it is inevitable that the population of school age in this county, which now is 32.8 percent, one of the highest in the state, will gradually diminish. The percentage for rural Michigan is down to 28.1 percent. Declining school-age population will affect school enrollments unless offset by increasing proportion of school age pupils who attend school.

SCHOOL ATTENDANCE BY AGE

Many forces affect school attendance, especially after the age of 12 to 14. Home influences are strong. The ethnic group of which parents and children are members may encourage teen-age education. The local educational environment may be stimulating or depressing.

The United States Census of 1940 indicates that Missaukee is in sixth place among the 83 counties of the state in school attendance of the farm children who are 5 and 6 years of age, slips to thirty-eighth place for those 7 to 13 years, occupies seventy-eighth position for the 14- and 15-year-olds, seventy-fourth for those 16 and 17 years, and seventy-third for those 18 to 20 years of age. The figures and percentages on which these ratings are based are presented in Table 1. It also indicates the counties ranking highest and lowest in school attendance of farm children for the different age groups. The formation of the McBain and Lake City Rural Agricultural Districts the past two years will undoubtedly spur an increasing proportion of youth in Missaukee County to pursue a high school education.

TABLE 1—*School attendance of the farm population of Missaukee County by years compared with highest and lowest counties, 1940.*[1]

Age	Number	Attending school	Percent Missaukee County	Rank among counties	Highest percent	Lowest percent
5–6	277	202	72.9	6th	98.4 Oceana	43.2 Saginaw
7–13	964	946	98.1	38th	99.4[2]	88.7 Ogemaw
14–15	310	238	76.8	78th	97.1 Iron	50.0 Keweenaw
16–17	262	126	48.1	74th	83.7 Luce	31.5 Presque Isle
18–20	355	48	13.5	73rd	35.6 Benzie	7.9 Presque Isle

[1]U. S. Census, 1940.
[2]Gogebic, Luce, Montmorency, and Wexford.

HIGH SCHOOL ATTENDANCE IN RELATION TO DISTANCE FROM SCHOOL, 1915-31

School attendance has been low for farm boys and girls in Missaukee County after completion of the eighth grade in country schools, except for those living near Lake City and McBain. As a rule, the farther the family lives from these cities, the less likely are the children to attend school. To be a member of a Christian Reformed family did not reduce the hazards. In recent years, the tragic condition of physical remoteness and isolation has been wiped out by the school bus, the high school tuition law, the expanded high school district, and the enriched curriculum in the rural agricultural schools. In three-fourths of Missaukee County, the opportunity for country children to secure a high school education is about as good now as it is for those in the cities of Lake City and McBain. Lake City has five school buses, McBain has seven, Merritt has six, Falmouth has three, and Norwich has three. These 24 school buses travel a total of 552 miles twice daily and transport 1,088 pupils. Besides, three school buses from Manton serve six districts in Missaukee County and transport 64 pupils daily.

Since 1935, the state has assumed the responsibility of paying the high school tuition up to a certain level, $113.50 at present, for every boy and girl whose residence is in a district not maintaining an approved high school. The methods developed for the payment of this tuition by each succeeding legislature have varied, but the important point is that the legislature has always considered it their duty to provide this tuition rather than for the district, the county, or the family to do so, as in many states.

High school attendance has been particularly low in the southern row of townships of Missaukee County—the Holland settlement. In this county, over a period of 16 years from 1915 to 1931, the average elementary school district had four youths per 100 children on the school census who were attending high school. For the six districts surrounding Lake City, it was 10, or five times as high as in the districts of Holland Township where it was two. During this decade and one-half, one of the more isolated districts never had a single pupil attending high school and several isolated districts of the county never had a pupil graduate from high school.

In rural school districts, school attendance is not compulsory for those under 16 who have completed the eighth grade, unless transportation is provided. Under such conditions, eighth grade education easily becomes terminal education. One is a teen-ager only once and education denied then cannot be recouped decades later. However, the addition of approximately 250 square miles, or nearly one-half of Missaukee County, to graded districts during the past two years, automatically

increased the number residing in compulsory school attendance areas. This will eventually boost the proportion attending high school.

CLOSED AND PARTLY CLOSED SCHOOLS

The process of equalizing educational opportunities in rural areas is frequently preceded by the closing or partial closing of schools. That is, many districts, before merging with others to form a rural agricultural or township district, may close the upper grade or grades or all grades and usually have their pupils transported to a graded school. The district with the closed school remains a quasi corporate body, has a school board, holds annual meetings, and maintains its autonomous existence as before. Of the 54 districts now comprising the five rural agricultural school districts, 23 went through this transition. Six districts had previously closed either the eighth grade or both the seventh and eighth grades, one for as long as six years. Twelve districts had closed completely, one for as long as nine years and six others had closed for six, seven, or eight years.

Of the 13 remaining primary districts in the county, seven are closed or partly closed, five of them since 1937-38. Probably within a few years the six which lie within the Manton trade and service area will be annexed to the Manton Rural Agricultural District. The Norwich Township Rural Agricultural District has transported its seventh and eighth grades to Lake City since 1932-1933. The Falmouth Rural Agricultural District formerly sent its pupils above the tenth grade to Lake City and now sends all high school pupils to McBain. High school pupils from the Merritt locality went largely to Lake City before high school grades were added to the Merritt school. This is clearly indicated in Fig. 1, which is based on a four-year average, 1928-32.

Arlene School has closed its eighth grade since 1937-38 with about one-half of the pupils going to Lake City and one-half to Manton. Pioneer School closed its seventh and eighth grades since 1938-39 except the last two years. Brunink School has been closed the last three years. Shippy School has closed its eighth grade since 1938-39. The Pleasant Hill School has been closed since 1937-38. The Stampfler School closed the eighth grade in 1938-39 and entirely since then. Rice School closed the seventh and eighth grades for two years beginning in 1937-38, then the eighth grade only for four years, and closed completely since then. Doyle School has been closed since 1937-38 except for two years.

A rural school once closed rarely reopens, and eventually annexes to another district, so that its electors may as well consider at the very beginning the proposition of annexation. The practice of the slogan, "Eventually, why not now?" is very fitting in this connection.

TEACHERS AND TEACHING CERTIFICATES

The generally low teaching qualifications of teachers in rural schools have been deplored for years. The war aggravated this condition. No alleviation of this situation appears to be near. It stimulates the closing of schools and the reorganization of districts. Of the 10 teachers employed by the school boards to teach in the elementary schools of Missaukee County last year, seven had War Emergency Certificates. Both of the teachers in the Norwich Rural Agricultural School also had War Emergency Certificates, three of the five teachers in the Falmouth Rural Agricultural School, five of the 13 teachers in the Merritt Rural Agricultural School, five of the 15 teachers in the McBain Rural Agricultural School, and only one of the 21 teachers in the Lake City Rural Agricultural School had a War Emergency Certificate. The inability to have capable and well-qualified teachers in rural schools encouraged school district annexations with graded districts.

RECOMMENDATIONS OF STUDY COMMITTEES AND COMMISSIONS

The inequalities in educational opportunities for rural children in Michigan, as in most areas of the 25 other states in which the district system prevails, in contrast with the county, township, or community system, have become increasingly apparent to both professional educators and laymen. To make studies of these inequalities in Michigan and make efforts toward their elimination has been the purpose of several commissions and legislative committees. In 1920, Wilford L. Coffey, then Assistant Superintendent of Public Instruction, prepared, under the direction of the legislative committee of the county commissioners of schools of Michigan, the findings and proposals of a study titled *Rural Education in Michigan*. It states, "The rural school of that day (spelling school, etc.), is gone. Those who wish for the rural school of the past may as well wish for the return of the stagecoach. The rural school of this state as an educational institution is hampered by educational traditions, by the small unit of taxation and administration, by the inefficient service rendered by untrained teachers, by inadequate supervision, and is controlled by those who, in most instances, have not had the vision to see the possibilities for rural school education. The problem confronting those who would improve our rural education is reorganization and redirection. The country child of Michigan today can have the opportunity for as good an education without leaving the school district, and at as small an expense as any city child of this state, if the rural people are made to see it . . . . A new type of rural school is therefore needed to prepare the rural child for the problems of this day."

The "new type of rural school" in Missaukee County seems to be the rural agricultural school. The Rural Agricultural School Act, giving special state aid to consolidated schools for the maintenance of school buses and the transportation of pupils, was passed in 1917 and became operative in 1919.

The Michigan Public Education Study Commission, which was appointed in 1942, made its report to the governor and the legislature in 1944. An integral part of its study involved the redrafting of maps of some 6,200 school districts, by counties, so as to bring them up-to-date. They had not been revised since they were originally drawn by the Department of Sociology, now Department of Sociology and Anthropology of Michigan State College, in 1934.[1] In this connection, the Commission indicated possible reorganization on the basis of the tenable principle of natural communities with relatively permanent centers of population having three million valuation, with possible exceptions in areas of low population density, as in Missaukee County.

The Commission indicated a "possible" reorganization of the county for consideration by any Missaukee County Committee on School District Reorganization that might be created. In this plan the five districts in the northwestern part of the county that had been served continuously by the Manton Public School and definitely lie in the Manton composite trade and service area, were rightly allocated to the Manton Rural School District. On the contrary, the five districts in the southern part of the county were probably unwisely assigned to the Marion R. A. District because, as a recent survey shows, it is not a homogeneous cultural area. The Commission did not have at its disposal at that time an "Ethnic Settlements" map of Missaukee County and its tributary area which might affect realignments of human interests and activities, more especially that of elementary and secondary education. Fortunately, delineations of all ethnic settlements within the rural areas of the state have since been completed and transferred to a township-outline map of the state.[2]

It is quite obvious now that the ethnic composition of the population of Missaukee County is such that a single school district for the entire county, excepting the portion lying in the Manton community, is inadvisable. The cultural pattern of the southern third of this county is quite unlike that of the rest of the county. It is a "Little Holland". In fact, McBain is near the center of a large settlement of Hollanders, the second largest Dutch settlement in the state.

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[1] J. F. Thaden and Eben Mumford, *High School Communities in Michigan*, Michigan Agricultural Experiment Station, Special Bulletin 289. 1938.

[2] J. F. Thaden, *The People of Michigan According to Ethnic Stocks* (map), Michigan Agricultural Experiment Station. 1945.

ELEMENTARY SCHOOL ATTENDANCE AREAS WITHIN A TWELVE-GRADE DISTRICT

Reorganization does not necessarily mean the closing of all one-room schools. The McBain people wisely operate, at least temporarily, elementary schools in convenient locations, as do all large city school systems. Rural localities with about 25 to 30 pupils in the lower elementary grades merit consideration as separate attendance centers within the school district. At Lucas, five and one-half miles northwest of McBain, a school is operated for 28 pupils in kindergarten and the first four grades. At Ardis, four miles southeast of McBain, 22 pupils are enrolled in kindergarten and the first four grades. Each is a one-teacher school.

RURAL AGRICULTURAL DISTRICTS REDUCE INEQUALITIES, INCREASE STATE AID

The economic phase of school district reorganization is important also. Wealth is very unevenly distributed, even within counties, townships and communities. Wealth tends to fluctuate with the coming and going of railroads, gas and oil wells, resort developments, land booms, and other factors. Variation in valuation per census child is many times greater between primary districts than between agricultural school districts, because of the latter's larger tax base.

The people of Norwich Township took a worthy step toward the equalization of fiscal capacity in 1923 by forming one district out of seven districts, with seven different schools, school boards, tax rates, etc. In 1922, the year before this merger, school census in the seven districts ranged from seven to 41, assessed valuation from $31,650 to $85,465, and valuation per census child from $1,274 to $6,346.

Assessed valuation zoomed in Norwich Township since the wells began pumping "black gold". It was $138,750 in 1942, $149,026 in 1943, $168,610 in 1944, $251,760 in 1945, and $318,150 in 1946. From 1942 to 1946, assessed valuation rose 12 percent in Missaukee County, while it increased 129 percent in Norwich Township. As long as these wells are producing, they may serve as barriers to the annexation of Norwich Township Rural Agricultural with Lake City school system of which it is an integral part. Thirty-two of the 43 oil and gas wells are in sections 1, 2, 10, 11, and 12, which comprised School District No. 7 before the Norwich Township R. A. was formed.

Another long step toward equalization was taken in 1930 when the 12 districts around Merritt merged. The year before this union, school census varied from two to 61, assessed valuation from $16,795 to $85,880,

assessed valuation per census child from $885 to $8,397, and school tax rate from 7 mills to 33½ mills. This merger resulted in a uniform assessed valuation of $1,980 per census child, and made the tax rate the same throughout the entire area. The formation of rural agricultural school districts around Falmouth, Lake City, and McBain likewise reduced inequalities within their respective localities. However, much remains to be done.

CONCLUSION

The completion of school district reorganization in Missaukee County is desirable, practicable, and financially worth-while, especially since it is not a wealthy county. In 1945, the State Board of Equalization placed the state-equalized valuation of Missaukee County at $5,000,000. In comparison with the state and with most other counties, this figure is low, because the equalized valuation when divided by the 1945 school census is only $2,210, as compared with $5,347 for the state. Furthermore, the state-equalized valuation per census child is higher in 80 counties than in Missaukee. The purpose of the state aid law is to compensate for such fiscal inequalities by giving aid to localities in proportion to need.

Reorganization gives farmers a chance to be represented on school boards of high schools attended by their children. Previous to 1931, considerably less than one-tenth of the farmers of Missaukee County had a voice in the election of the school boards of graded schools. A few had this franchise by virtue of the fact that they lived close to Lake City and McBain, and within their twelve-grade districts. Now about three-fourths of the farmers have this privilege. A majority of the school board members of each reorganized district are farmers just as their children constitute a majority of the school enrollment.

In Missaukee County but within the Manton community lie five school districts of approximately the same size. However, the assessed valuation is over twice as high in Stampfler as in Pleasant Hill, school census is over four times as high in Shippy as in Pleasant Hill, and assessed valuation per census child is over twice as much in Pleasant Hill as in Shippy. These districts, together with Rice and the western half of Arlene, have a valuation of $226,970, a school census of 129, and a valuation per census child of $1,759. These districts, three of which are closed and the three others are partly closed, should be annexed to the Manton Rural Agricultural District.

The Lake City community comprises the school districts of Lake City, Jennings, Pioneer, Sunnyside, Fifield, eastern half of Arlene, Norwich Township Rural Agricultural and the Merritt Rural Agricultural, excluding Holland Township, which lies in McBain community. The

pioneer district has a valuation of $41,080, a school census of 42, and therefore $978 valuation per child, the lowest of the eight districts. At the other extreme, at present, because of 43 oil and gas wells, is Norwich Township Rural Agricultural with a valuation of $319,010. Its school census is 104, resulting in each child having $3,067 back of him.

The annexation of the remaining districts in Lake City community, as indicated above, with the Lake City Rural Agricultural gives it a state equalized valuation of $2,380,333, a school census of 1,032, with an elementary school membership of 589 and a secondary school membership of 308. On this basis, combining Lake City, Jennings, Pioneer, Sunnyside, Fifield, eastern half of Arlene, Norwich, and Merritt school districts, excluding Holland Township, the total state aid payments would be $72,980, or $2,217 more than under the present system of separate districts. In merging of districts lie possibilities of increasing state aid, besides eliminating local inequalities, and enriching the curriculums.

The McBain community comprises the school districts of McBain, Brunink, Bosscher, Prosper, Falmouth, Holland Township, and the four school districts in Highland Township of Osceola County, Keys, Highland Corners, Maplecrest, and Maple Ridge. In this community, Bosscher, Brunink, and Highland Corners districts have the lowest valuations per census child, $1,183, $1,212, and $1,111 respectively, while McBain and Falmouth districts have the highest, $1,841 and $1,608 respectively. The annexation of the remaining districts in McBain community, as indicated above, with the McBain Rural Agricultural District gives it a state equalized valuation of $2,723,575, a school census of 1,318, with an enrollment in the elementary grades of the public schools of 484, and in the secondary grades of McBain Rural Agricultural of 198. By combining these districts into one rural agricultural district the state aid payments would amount to $49,030, or somewhat less than under the present system of separate districts. This is accounted for mainly by the fact that in five of the districts where the number of children on the school census was relatively high, the district received no state aid other than the primary money. In these districts, there were a large number of children attending parochial schools. At present, there is a total of 185 elementary school children and 137 secondary school children attending the parochial schools. If these pupils were all in attendance in the public schools, as they are likely to be during periods of economic depression, the state aid would be increased by $24,708 over that of last year.

The intelligent method of procedure in any effort to equalize educational opportunities is for the residents who live within the area served by a 12-grade accredited public school to evaluate the advantages

of forming a community school district, and forming such a district all at once, instead of piece-meal. They should consider the extent to which inequalities can be eliminated thereby, the extent to which state aid will be increased, the greater benefits that pupils will derive therefrom, and the advantage of being so organized as to be eligible for state and federal school building funds, if and when such are available.

THE FAIRHAVEN PEACH

By STANLEY JOHNSTON
SECTION OF HORTICULTURE

IN CONTINUANCE of its efforts to develop better commercial peach varieties maturing earlier than Elberta, the Michigan Agricultural Experiment Station announces the introduction of the Fairhaven variety.

Fairhaven originated at the South Haven Experiment Station from a cross made between J. H. Hale and South Haven (J. H. Hale x South Haven) in 1930.

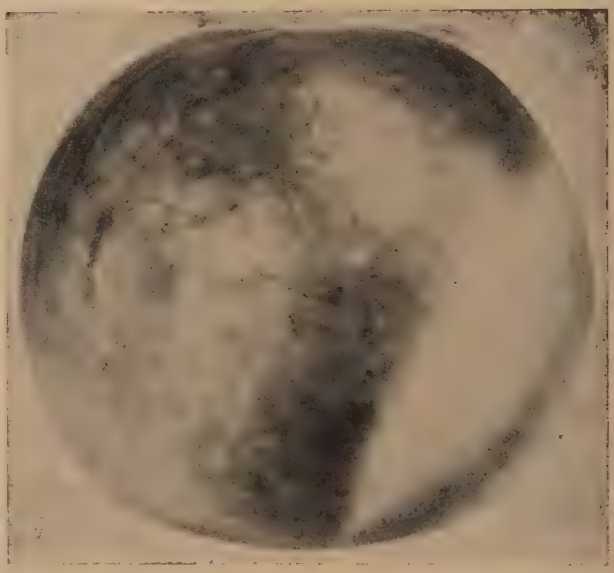

Fig. 1. The Fairhaven peach.

The season of maturity of Fairhaven is about a week before Halehaven and at the end of the Redhaven season. At least half of the fruits of Golden Jubilee will have been harvested when the Fairhaven season begins.

Trees of Fairhaven have shown no marked weakness to date and are vigorous and productive. Strong scaffold limbs are formed and there has been no indication of susceptibility of the trunk to winter injury.

The production record of this new variety has been remarkably good. The original tree produced well and progeny trees, which started bearing in 1939, have produced full crops annually at the South Haven Experiment Station. No extremely cold winters were experienced at South Haven during this period, but other tests indicate that fruit buds of Fairhaven are about as resistant to cold as those of Halehaven. During two spring blossoming periods, 1943 and 1945, the weather was extremely cold and foggy, yet full crops were produced, and trees of many other varieties were unproductive.

ARTICLE 29-10

Fairhaven has the same tendency for heavy fruit setting as Halehaven and Redhaven, but produces fruits of larger size than these two varieties under heavily loaded conditions. While heavy setting makes more pruning and thinning necessary, it is a valuable characteristic, for varieties having it usually have very dependable production records.

Fruits of Fairhaven are medium-large, nearly round, and mostly bright golden in color, with an attractive bright red cheek. The skin is smooth and very tough. The golden color becomes bright while the fruit is still firm. The fruits are very firm and ship exceptionally well for an early peach.

The flesh is medium-yellow with a moderate amount of red color at the pit, moderately fine-textured and of good flavor. It resists browning, which is a great advantage, especially in processing. The stone is free when the fruits are fully ripe.

Fairhaven is not perfect. There is no perfect variety. Mother Nature is extremely reluctant to bestow all of her good things on one individual. However, Fairhaven has scored high in a long comparative test and should be of value in its particular season of ripening. Prospective growers of this variety should give careful consideration to its season of maturity. For some, this character will prove profitable, while for others, it will not, because of competition from other fruit-producing areas, or Fairhaven's inability to fit into the local orchard program.

Promising new varieties should be tested by progressive fruit growers but in a moderate way at first until their true value is determined. Fairhaven is no exception.

FEEDING AND CONFINEMENT REARING EXPERIMENT WITH TURKEYS DURING 1944

By F. N. BARRETT, C. G. CARD and ASHLEY BERRIDGE
SECTION OF POULTRY HUSBANDRY AND LAKE CITY EXPERIMENT STATION

THIS REPORT is the tenth of a series of studies, the objectives of which is to explore certain fields that may suggest possibilities for increasing turkey production efficiency. Confinement rearing methods are employed, because they make possible a better control of the factors of production. The establishment of a fund of dependable data over a considerable period of time and under comparable conditions of environment and management has proven to be a most important part of these experiments.

These studies were started in 1935, and each year the same brooding, rearing and management methods have been strictly practiced in order to prevent, insofar as possible, the injection of environmental factors which in themselves might influence the results. The same strain of Bronze turkeys is used each year to represent this breed, and to serve also as a check group for comparing birds of other breeding. Mash 7 has proven to be an excellent all-purpose mash that is adequate for normal growth and the excellent development of turkeys reared under confinement conditions. Since 1936, this mash, with its later accompaniment of grain, has been included each year as a check ration with which the results of other feed combinations are compared. The annual experiments thus have a close relationship to each other because the basic conditions and manner of presenting data are comparable.

When deemed of sufficient importance, certain of the feeding trials and trials with turkeys of different breeding are repeated for more than one year to check possible seasonal variations and the consistency of results. Turkeys of different breeding are commonly tried with more than one feed combination, or perhaps with a trial on a cobblestone yard as compared with the usual experimental turkey house.

As these studies progress, the usefulness of data becomes increasingly apparent. In this connection, the results of the 1942 trials with wheat and oats as grain were interesting but did not in themselves strongly reveal the value of wheat in the diet of turkeys. However,

ARTICLE-29-11

when these trials are combined with those of an enforced use of wheat in 1944 a definiteness of trend as to the usefulness of this grain during the growing period is strongly suggested.

The 1938 and 1939 trials with the free-choice feeding of corn, wheat, oats and barley revealed the value of oats for growth and, especially, the tendency of this grain to bring about a material reduction in the amount of the more expensive mash that turkeys will consume per pound of gain. It is of interest to note that in 49 trials with Standard Bronze turkeys (1936-43), with virtually the same mashes as currently used and corn as the only grain, an average of 3.23 pounds of mash and 4.59 pounds of total feed was consumed for each pound of gain. In 10 trials (1940-43) with similar mashes but with both corn and oats fed in a free-choice manner, an average of 2.16 pounds of mash and 4.60 pounds of total feed was consumed per pound of gain. This ability to use more farm grown grain and less of the more costly mash has resulted in a material reduction in production costs.

1944 OBJECTIVES

The 1944 trials include a continuation of studies with reference to the grain part of the diet and possible factors that may influence the proportion of grain to mash that turkeys consume. Previous trials had indicated that the hopper feeding of whole oats, with either corn or wheat, materially increased the proportion of whole grain and reduced the proportion of mash which turkeys will consume per pound of gain; as a result, costs tended to be cheaper and final weights somewhat heavier. Although whole oats are commonly considered as desirable for growth rather than finishing value, turkeys will continue to eat oats enthusiastically from the start to the end of the feeding period. In the 1944 trials, as in the previous year, the pens receiving oats in combination with other grains (except Pen 9) were gradually reduced in the amount offered after the eighteenth week and oats were entirely discontinued after the twentieth week. Two house pens with the same mash, were used to check the results with oats as the only grain for different periods. Two mashes which are wartime modifications of Mash 7, were included this year. These were mashes 18 and 19 which contain less meat scrap and dried milk and more soybean oil meal and dried whey. Both mashes 18 and 19 were relatively high in soybean oil meal, the amounts being 27 and 35 percent, respectively. 1944 was a difficult year for conducting experiments and it was necessary to modify the original plan in two respects. First, was a wartime change by the manufacturer in the original formula for Mash 7 which was discovered too late to rectify. (See Table 1 for formula and notation of change.) Second, the original plan called for using corn and oats in

different combinations with the several mashes. As the season advanced it was found that corn could not be purchased until late in the season, except at illegal prices. Consequently, it was necessary to use wheat until the twentieth week, at which time corn was substituted for the wheat for the last six weeks in each trial where both corn and wheat are indicated.

Cost and rearing studies were continued with Standard Bronze, Broad Breasted Bronze, and Beltsville Small White turkeys. The Broad Breasted Bronze were used for the first time this year, with only 17 birds available for the trial. These three varieties were used with several different mash and grain combinations and also in cobblestone yard trials.

Observations on the practicability of using a permanent turkey house and also as to the use of cobblestone yards for the rearing of market turkeys and the control of losses is a continuing project. The data on the three cobblestone yard pens used in the trials this year are presented as pens 11, 12 and 13. The mashes used and the feeding plan are given in tables 1 and 1A, respectively.

INCUBATION AND STARTING METHODS

The poults used in these trials were hatched from eggs produced by the breeding flocks at Lake City Experiment Station. The hatching dates for the different pens are given in Table 1-A. The young poults

TABLE 1—*Rations.*

Mash number	7–A*	18	19
Protein content of mash (percent)	25.44	23.38	25.94
Ground yellow corn	11.4	10	8
Ground oats	15	15	12
Wheat bran	10	10	7
Wheat flour middlings	10	8	10
Meat scrap	12.6	7	7
Dried milk	10	—	—
Dried whey	—	9	6
Soybean oil meal	22	27	35
Alfalfa meal (17% dehydrated)	5	8	8
Calcium carbonate	1	1	2
Steamed bone meal	—	2	2
Salt	1	1	1
Cod liver oil (85 D units)**	2	2	2
Total	100	100	100
Manganese sulfate added per ton (ounces)	8	8	8

*Mash 7–A similar to the original mash 7 except that meat scrap was reduced 1.4 pounds and ground corn was increased by this amount. As a result, the protein content was lowered approximately 1 percent. This was a wartime change by the manufacturer which was discovered too late to rectify.

**Cod liver oil was discontinued in all rations after about the sixteenth week.

TABLE 1-A—*Feeding plan.*

Pen	Breeding	Number of birds	Hatching date	Mash	Grain*	
					8 to 20 weeks	20 to 26 weeks
1	Bronze	25	April 25	7A	Wheat	Corn
2	Beltsville	25	April 25	7A	Wheat	Corn
3	Bronze	25	May 9	7A	Wheat, oats	Corn
4	Beltsville	25	May 9	7A	Wheat, oats	Corn
5	Bronze	25	June 6	19	Wheat, oats	Corn
6	Bronze	25	June 6	18	Wheat, oats	Corn
7	Beltsville	25	June 6	19	Wheat, oats	Corn
8	Bronze	25	June 30	7A	Oats	Oats
9	Bronze	25	June 30	7A	Oats	Corn
10	Beltsville	25	June 30	18	Wheat, oats	Corn
11	Bronze	25	May 22	7A	Wheat, oats	Corn
12	Beltsville	25	May 22	7A	Wheat, oats	Corn
13	Broad Breast	17	May 22	7A	Wheat, oats	Corn

Mash was available at all times from the first day to the end of the trials.

*Grain was added to all diets at the end of the eighth week and was fed in a free-choice manner from then on to the finish with certain modifications as indicated above, except that with Pen 9 oats were continued to the end of the twenty-second week.

were kept for the first 12 to 24 hours in baby chick boxes. At the end of that time they were placed under small brooders in lots of about 50 each. Mash 7 in hoppers, together with water in vacuum fountains, was the only food given for the first week. In all trials previous to 1943 burlap was used as a floor covering for the first 3 or 4 days, after which time fine shavings were used until the birds were removed to Lake City. Starting in 1943, the day-old poults were started at once on shavings with apparently equally good results.

EXPERIMENTAL PENS AT EAST LANSING

At the end of the first week, the poults were sorted into experimental lots of 25 each. Each lot was provided with an indoor floor pen, 4½ feet wide and 10 feet long, with an electric hover. Perches were added when the hovers were no longer required.

Because of restricted space in the laboratory, it was necessary to remove each group to quarters in a laying house when they were 4 weeks of age. With each lot, it was necessary to keep the poults under the conditions described until their age and the weather conditions made it possible to transfer them to the large, open-front house at Lake City. This was between 7 and 8 weeks of age for each group.

THE LAKE CITY TURKEY HOUSE

At the Lake City Station, each group of 25 turkeys (with the exception of yard pens 11, 12 and 13) was confined to a pen 10 feet wide and 24 feet long in the open-front turkey house. This building, which

TABLE 2—*Proportion of mash and grain consumed.*
(Total mash and grain consumed equal 100)

Pen	0–4 weeks		5–8 weeks		9–12 weeks		13–16 weeks		17–20 weeks		21–24 weeks		25–26 weeks	
	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain
1	100	0.0	100	0.0	76.9	23.1	63.7	36.3	55.3	44.7	44.9	55.1	37.3	62.7
2	100	0.0	100	0.0	89.1	10.9	73.5	26.5	48.6	51.4	57.4	42.6	34.6	65.4
3	100	0.0	100	0.0	71.9	28.1	54.6	45.4	51.3	48.7	36.1	63.9	19.3	80.7
4	100	0.0	100	0.0	82.7	17.3	70.0	30.0	55.5	44.5	55.1	44.9	31.0	69.0
5	100	0.0	100	0.0	73.4	26.6	62.2	37.8	40.8	59.2	28.1	71.9	13.3	86.7
6	100	0.0	100	0.0	72.9	27.1	65.8	34.2	44.8	55.2	32.8	67.2	15.2	84.8
7	100	0.0	100	0.0	87.2	12.8	78.7	21.3	47.0	53.0	30.0	70.0	18.6	81.4
8	100	0.0	100	0.0	88.2	11.8	62.8	37.2	35.0	65.0	22.6	77.4	15.6	84.4
9	100	0.0	100	0.0	66.4	33.6	53.2	46.8	30.1	69.9	21.1	78.9	6.3	93.7
10	100	0.0	100	0.0	87.3	12.7	84.8	15.2	45.0	55.0	35.7	64.3	18.5	81.5
11	100	0.0	100	0.0	81.3	18.7	44.9	55.1	32.8	67.2	26.7	73.3	9.7	90.3
12	100	0.0	100	0.0	83.1	16.9	58.8	41.2	42.8	57.2	37.7	62.3	29.4	70.6
13	100	0.0	100	0.0	90.5	9.5	61.9	38.1	44.9	55.1	41.5	58.5	25.0	75.0

is 100 feet long, is constructed of rough lumber and poles. The house is divided into pens with wire and wood partitions. At the end and back walls are hinged panels that may be opened for ventilation in summer. At the rear of each pen are perches and a dropping board. The floors are of concrete, and chopped straw is used as litter.

FEEDING PLAN

The original feeding plan for the 1944 season provided for the use of corn and oats as single grains and also combined, in connection with the different mashes. Because of the inability to purchase corn at legal prices until late in the season, it was necessary to use wheat until the turkeys were 20 weeks of age when wheat was discontinued and corn feeding started for the remainder of the trials. Thus, wheat was fed only from the eighth to the twentieth week and corn was fed only from the twentieth week to the finish, with all pens where either of these grains is indicated in the outlined Feeding Plan, Table 1-A. Where oats are indicated in Table 1-A, they are fed only from the eighth to the twentieth week, as with wheat, except with pens 8 and 9. Pen 8 received oats as the only grain for the entire grain feeding period, while Pen 9 had only oats until the twentieth week, when corn was added, and only corn after the twenty-second week when oats were discontinued. With Mash 7-A (for the 8 to 20 week period), pens 1 and 2 were fed only wheat, pens 8 and 9 only oats, while house pens 3 and 4 and yard pens 11, 12 and 13 were fed both wheat and oats. Mash 18 was fed to pens 6 and 10 and mash 19 to pens 5 and 7 with both wheat and oats during this period. All pens, except Pen 8, had only yellow corn as grain after 20 weeks.

Rearing and cost studies with Standard Bronze turkeys were conducted with birds in pens 1, 3, 5, 6, 8, 9 and 11; with the Beltsville Small White turkeys in pens 2, 4, 7, 10 and 12; and with Broad Breasted Bronze in Pen 13. Standard Bronze and Beltsville turkeys are comparable under different conditions in pens 1 and 2, 3 and 4, 5 and 7, 6 and 10, and 11 and 12, as the management and diet is the same in each grouping. A comparison of housed turkeys with yarded birds on the same diet may be made with Standard Bronze in pens 3 and 11, and Beltsville turkeys in pens 4 and 12. Standard Bronze, Beltsville and Broad Breasted Bronze are comparable in yard pens 11, 12 and 13, respectively. The results under different conditions, with either the Bronze or Beltsville variety, may be observed by examination of the several tables which accompany this report.

RESULTS

Turkeys Lacked Finish When Fed Oats as Only Grain

The Standard Bronze turkeys (Pen 8) with Mash 7-A and only oats as grain from the eighth week to the end of trial, showed very poor finish and were very unattractive in appearance at 26 weeks of age. These birds did not show fat on backs, the surface color was dark with absence of fat under skin, and they had more short pin feathers than any of the other pens. When drawn, these turkeys had very little abdominal fat and what they did have was soft and stringy and of an unattractive yellow color. The average male weight at 26 weeks of age was next to the lowest, for the seven Bronze pens, but the females were tied with Pen 11 for the heaviest average weight. The cost per pound of gain, at this year's feed prices, was next to the highest and 2.2 cents per pound more costly than the lowest for the breed.

Pen 9 turkeys had the same diet as Pen 8, except that at twenty weeks of age corn was provided and after an adjustment period of two weeks, oats were entirely eliminated from the diet. Pen 9 turkeys had rich yellow surface color, plenty of back and skin fat, and the abdominal fat was abundant, firm and of good color at the end of the trial. The average male weight for Pen 9, however, was the lowest for all seven Bronze pens and the average female weights were tied for lowest place. The average cost per pound of gain was 2/10 cent cheaper than with Pen 8.

Small-type Turkeys Consume Slightly More Mash and Total Feed than Standard Bronze

In considering 18 separate trials (1939-44) in which small-type turkeys were fed several different mash and grain rations in a free-choice manner in direct comparison with turkeys of the Standard Bronze

breed, there appears to be a very definite tendency for the small-type birds to consume slightly more mash and total feed per pound of gain than the larger turkeys. Included in these trials were 4 pens of small-type Bronze (1939-41) and 14 pens of Beltsville Small White turkeys (1941-44). In every instance in these 18 trials, the small-type birds consumed slightly more mash and, in 16 of the 18 trials, slightly more total feed per pound of gain than the Standard Bronze. The 4 small-type Bronze trials averaged 0.14 pound more mash and 0.3 pound more total feed, while the 14 Beltsville trials averaged 0.56 pound more mash and 0.34 pound more total feed per pound of gain than the Standard Bronze. The average cost of producing Beltsville turkeys was 1.74 cents more per pound than with Standard Bronze in these 14 trials.

Wheat as Grain Produced Economical Gains But Wheat and Oats Produced Heaviest Turkeys

The Bronze turkeys in Pen 1 and the Beltsville turkeys in Pen 2, with Mash 7-A and wheat as the only grain for the first 20 weeks, produced gains on the smallest amount of total feed and also at lower cost than corresponding turkeys in Pen 3 and 4 with the same mash but with both wheat and oats. The Pen 1 Bronze birds produced gains with 0.41 pound less total feed and at 1.3 cents cheaper cost than corresponding turkeys in Pen 3. Only 3.74 pounds of total feed was consumed per pound of gain and this, as well as the cost per pound of gain of 13.4 cents, was the lowest for any of the 13 trials and irrespective of breed. The Beltsville turkeys on the same ration in Pen 2 produced gains with 0.35 pound less total feed and at 1.4 cents less cost per pound than Beltsville turkeys in Pen 4, which had both wheat and oats. The Beltsville turkeys in Pen 2 produced gains with less total feed and at lower cost than did any of the other five pens of this breed. However, when the final weights at 26 weeks of age are considered, the Pen 3 males average 1.7 pounds heavier and the females 0.8 pound heavier than the Bronze turkeys in Pen 1. Likewise, the average weight of Beltsville males in Pen 4 was 0.8 pound heavier and the females 0.4 pound heavier than with the Beltsville birds in Pen 2. Pen 4 males and females had heavier final weights than any of the other five Beltsville pens, and Pen 3 males were the heaviest and Pen 3 females 0.1 pound under the heaviest when all seven Bronze pens are considered. Table 5 presents the data with reference to the growth of turkeys and includes the average final weights at 26 weeks of age.

Is Wheat More Efficient Than Corn for Early Growth?

The 1942 trials with wheat and oats and the 1944 trials, in which wheat was the only grain fed during the first 20 weeks of age, strongly suggest that wheat is more efficient than corn for feeding during the early growth period. Considering a 10-trial average (1935-41) with Mash 7, and corn as the only grain fed Standard Bronze turkeys, the birds consumed 69.6 parts of mash to 30.4 of grain with an average of 4.32 pounds of total feed per pound of gain. In the 1944 trials, the Pen 1 Bronze birds, with Mash 7-A and wheat as the only grain until 20 weeks of age, consumed 61.2 parts of mash and 38.8 parts of grain and only 3.74 pounds of total feed per pound of gain. Thus the wheat fed birds consumed 0.72 pound less mash and 0.58 pound less total feed for each pound of gain. In a single trial (1942) with Beltsville turkeys on Mash 7 with corn as the only grain, the turkeys consumed 77.0 parts of mash to 23 parts of grain with 4.87 pounds of total feed per pound of gain. In the 1944 trials, Pen 2 Beltsville turkeys, with Mash 7-A and wheat as the only grain to 20 weeks, the birds consumed 68.0 parts of mash to 32.0 parts of grain and only 4.28 pounds of total feed. In these latter trials the wheat fed Beltsville turkeys consumed an average of 0.84 pound less mash and 0.59 pound less total feed for each pound gain. Thus, there appears to be a tendency for turkeys to consume a smaller quantity of mash and also a smaller amount of total feed per pound of gain when wheat, rather than corn, is fed as a single grain during the early growth period.

When Mash 7 is fed with both corn and oats as compared with wheat and oats under the same conditions, there is also a tendency for wheat and oats to bring about a material reduction in the amount of mash consumed but not in the total feed per pound of gain. In considering a 10-trial average (1940-43) with Bronze turkeys on Mash 7 with corn and oats as grain, the birds consumed 47.0 parts of mash and 53.0 parts of grain with an average of 4.60 pounds of total feed. In the 1942 trials, the Pen 4 Bronze birds on Mash 7 with wheat and oats as grain, consumed only 36.1 parts of mash but 4.79 pounds of total feed per pound of gain. This tendency is also pronounced with limited trials with Beltsville turkeys. In a single trial (1943) with Mash 7, and corn and oats, the Beltsville turkeys consumed 61.3 parts of mash and 38.7 parts of grain with an average of 4.78 pounds of total feed. A single trial (1942) with the same mash but with wheat and oats as grain, Beltsville turkeys consumed only 44.7 parts of mash and 55.3 parts of grain with an average of 4.76 pounds of total feed per pound of gain. In these multiple grain trials, the wheat and oat fed turkeys consumed an average of 0.43 pound less mash with Bronze turkeys and 0.8 pound

less mash with Beltsville birds per pound of gain than with the same breeds fed corn and oats as grain.

The mash is the most expensive part of the diet and important variations in the amount of mash, which turkeys consume under a free-choice system, have an important influence on production costs.

TYPE STUDIES

Comparisons may be made, in the tables accompanying this report, as to the differences that may exist between Standard Bronze, Broad Breasted Bronze and Beltsville Small White turkeys on the same diet and under different conditions. The Broad Breasted Bronze turkeys, which were included in limited number for the first time this year, were highly efficient in the use of feed, growth rate, and in cost per pound of gain. They produced the heaviest final weights with both male and female, and were second only to Pen 1 Standard Bronze turkeys in total feed per pound of gain and in cost. It should be mentioned in this connection that yarded turkeys are usually less efficient than housed birds and there was a slight difference in the grain part of the ration which may be noted in Table 1-A. Five pens of Beltsville Small White turkeys were included in this year's trials and are reported as pens 2, 4, 7 10 and 12. The Beltsville turkey has proven to be a very excellent variety for its type. At 26 weeks of age the males usually weigh from 14 to 16 pounds and the females from 8 to 10 pounds. It produces remarkably well fleshed and compact carcasses with an exceptional number that will grade A or AA when finished. However, in numerous trials, they have required slightly more feed per pound of gain and have tended to consume a somewhat higher percentage of their total feed in the form of mash than the Bronze variety. As compared with our strain of Standard Bronze turkeys, the Beltsville variety has tended to cost from 1 to 2 cents more per pound to produce, but their superior carcass should command a premium price in discriminating markets that should more than off-set this price difference. Breed and type observations are a continuing project and an analysis of data is made at such times as differences of importance are observed.

FEED CONSUMED PER POUND OF GAIN

In computing the efficiency of a diet it is advisable to consider the proportion of mash to grain, as well as the total quantity of these ingredients, required to produce a pound of gain (Table 3). When oats are hopper fed with corn or wheat, or with both of these grains, turkeys tend to consume less mash and more grain than when either corn or wheat is fed as a single grain. Slightly more total feed per pound of

TABLE 3—*Pounds of feed consumed per pound of gain.*
(Average to 24 weeks of age)

Feed	Pen												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Mash	2.29	2.91	2.29	3.09	2.11	2.44	2.70	2.28	1.98	2.95	2.04	2.58	2.27
Corn	.39	.28	.75	.63	.69	.69	.68	.....	.89	.73	1.00	.77	.65
Wheat	1.06	1.09	.25	.31	.67	.69	.62	.....	.....	.48	.87	.78	.49
Oats	.....	.....	.86	.60	.70	.69	.55	2.28	1.71	.69	.59	.59	.44
Mash and grain total	3.74	4.28	4.15	4.63	4.17	4.51	4.55	4.56	4.58	4.85	4.50	4.72	3.85

gain is usually consumed in this multiple grain feeding but the cost per pound of gain is usually less. Turkeys in yard pens tend to consume slightly more feed per pound of gain than corresponding birds in the turkey house. Likewise, small- type turkeys tend to consume slightly more feed per pound of gain than the larger varieties. The proportion of feeds by periods and the average pounds of mash and grain consumed per pound of gain to 24 weeks of age are given in tables 2 and 3, respectively.

AVERAGE COST OF PRODUCING A POUND OF GAIN

In determining the merits of any ration, obviously the cost of producing a unit of gain is one of the factors to be considered. This information is given in Table 4. Consideration should also be given to the normal development of the birds, the growth rate, the character

TABLE 3-A—*Pounds of feed consumed per pound of gain.*
(Distributed by periods)

Pen	1–4 weeks		5–8 weeks		9–12 weeks		13–16 weeks		17–20 weeks		21–24 weeks		25–26 weeks	
	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain
1	2.37	0.0	2.78	0.0	2.11	0.64	2.33	1.33	2.09	1.69	2.51	3.08	2.54	4.27
2	2.49	0.0	3.17	0.0	2.86	0.35	3.01	1.08	2.04	2.16	4.20	3.12	2.50	4.73
3	2.78	0.0	2.93	0.0	2.25	1.09	2.37	1.97	2.53	2.40	1.76	3.11	0.97	4.04
4	2.70	0.0	2.79	0.0	3.06	0.64	3.57	1.54	2.88	2.28	3.22	2.63	1.97	4.38
5	2.86	0.0	2.91	0.0	2.27	0.82	2.41	1.46	1.77	2.57	1.76	4.51	1.05	6.84
6	3.66	0.0	3.50	0.0	2.67	0.99	2.86	1.49	2.10	2.59	1.89	3.88	1.35	7.52
7	3.74	0.0	3.83	0.0	3.19	0.47	3.23	0.87	2.08	2.35	2.02	4.71	2.08	9.13
8	2.75	0.0	3.12	0.0	3.23	0.43	2.40	1.43	1.92	3.55	1.45	4.84	1.64	8.86
9	2.64	0.0	2.88	0.0	2.12	1.07	2.02	1.78	1.72	3.99	1.59	5.92	.55	8.20
10	2.69	0.0	3.87	0.0	3.21	0.47	3.54	0.63	2.41	2.95	2.60	4.70	1.62	7.16
11	2.72	0.0	2.95	0.0	2.45	0.56	1.85	2.28	1.62	3.32	1.96	5.38	0.70	6.52
12	2.55	0.0	3.05	0.0	2.77	0.56	2.74	1.92	2.14	2.86	2.81	4.64	9.79	23.55
13	2.64	0.0	2.69	0.0	2.65	0.28	2.38	1.47	1.82	2.23	2.19	3.09	2.41	7.24

TABLE 4—*Feed cost per pound of gain.*
(Average to 24 weeks of age)

Feed	Pen												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Mash	$0.097	$0.124	$0.097	$0.131	$0.087	$0.107	$0.111	$0.097	$0.084	$0.130	$0.087	$0.110	$0.096
Corn	0.012	0.008	0.022	0.019	0.020	0.020	0.020	.....	0.026	0.022	0.030	0.023	0.019
Wheat	0.025	0.026	0.006	0.007	0.016	0.016	0.015	.....	.....	0.011	0.020	0.018	0.012
Oats	.....	.....	0.022	0.015	0.018	0.018	0.014	0.059	0.044	0.018	0.015	0.015	0.011
Mash and grain total	$0.134	$0.156	$0.147	$0.172	$0.141	$0.161	$0.160	$0.156	$0.154	$0.181	$0.152	$0.166	$0.138

of the finished product, and any other advantage or disadvantage of a particular ration before final conclusions are made. A ration that produces the cheapest gains in one year may not be as economical in another year because of changing prices. This is especially true as regards the grains that are used. Thus in 1944, the price paid for corn was 70 percent of the cost of mash while wheat was obtainable at 55 percent of the cost of mash. Under such conditions, rations using relatively large amounts of wheat may produce cheaper gains than if the situation is reversed.

FEED PRICES

The average prices paid per 100 pounds for the different mashes and grains this year were: Mash 7, $4.25; mash 18, $4.40; mash 19, $4.10; whole corn, $2.95; wheat, $2.35; and oats, $2.60. Since 1939, the prices paid for grains have tended to advance out of proportion to those of

TABLE 5—*Growth of turkeys.*
(Average weight in pounds)

Pen	4 weeks		8 weeks		12 weeks		16 weeks		20 weeks		24 weeks		26 weeks	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
1	.81	.73	2.5	2.0	5.2	4.1	9.0	6.6	13.1	8.9	16.8	10.7	18.5	11.6
2	.65	.56	1.9	1.6	4.3	3.3	7.1	5.2	10.4	7.0	12.8	8.4	14.4	9.0
3	.82	.70	2.5	2.1	5.5	4.3	9.3	6.8	13.3	9.2	17.8	11.4	20.2	12.4
4	.64	.59	2.0	1.7	4.2	3.4	7.1	5.4	10.0	7.1	13.7	8.7	15.2	9.4
5	.68	.69	2.0	1.9	5.0	4.3	8.8	6.9	13.7	10.1	17.9	11.8	19.6	12.4
6	.62	.60	1.7	1.4	4.2	3.4	7.5	5.8	12.0	8.6	16.3	11.1	18.0	11.9
7	.63	.59	1.7	1.5	3.8	3.1	6.6	5.2	10.3	7.3	13.3	8.7	14.3	9.0
8	.79	.74	2.3	2.0	4.8	4.2	8.7	7.5	12.4	9.9	16.2	11.9	17.1	12.5
9	.79	.76	2.3	2.0	5.0	4.3	8.9	7.0	12.6	9.3	15.8	10.9	17.0	11.6
10	.52	.48	1.5	1.2	3.5	2.6	6.5	4.6	9.8	6.5	12.6	7.8	13.7	8.2
11	.78	.67	2.2	1.9	5.3	4.4	9.4	7.2	13.7	10.1	16.9	12.2	18.5	12.5
12	.67	.60	1.8	1.5	4.2	3.2	7.2	5.0	10.8	7.0	13.6	8.1	13.9	8.1
13	.75	.71	2.5	2.2	6.2	5.0	10.9	8.2	16.2	11.5	21.2	14.3	22.9	14.8

TABLE 6—*Final weights of turkeys in pounds at 24 weeks of age.*

	Pen												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Birds started	25	25	25	25	25	25	25	25	25	25	25	25	17
Surviving birds	25	25	25	25	22	23	25	23	23	24	25	25	17
Total weight (lb.)	371.3	253.5	382.7	286.9	344.4	308.3	276.6	350.4	315.0	244.5	370.9	290.8	290.9
Number of males	17	10	16	14	14	10	13	18	13	12	14	16	7
Heaviest male (lb.)	18.5	14.6	21.1	15.2	20.7	13.2	15.2	19.5	20.1	14.7	21.5	15.3	24.5
Lightest male (lb.)	13.3	10.8	13.0	11.4	15.3	13.2	11.5	12.7	11.2	11.0	14.2	10.6	17.7
Average weight (lb.)	16.8	12.8	17.5	13.7	17.9	16.3	13.3	16.2	15.8	12.6	16.9	13.6	21.2
Number of females	8	15	9	11	8	13	12	5	10	12	11	9	10
Heaviest female (lb.)	12.5	9.2	13.4	9.6	12.9	13.3	9.6	12.5	12.0	9.3	13.7	8.4	17.1
Lightest female (lb.)	7.7	7.2	9.8	7.2	9.3	9.5	8.3	11.1	9.5	7.0	10.1	8.0	12.1
Average weight (lb.)	10.7	8.4	11.4	8.7	11.8	11.1	8.7	11.9	10.9	7.8	12.2	8.1	14.3

mashes in some instances. A comparison between the feed prices of 1944 and 1939 reveals that Mash 7 advanced 170 percent, shelled corn 222 percent, wheat 151 percent, while whole oats showed an increase of 260 percent. This unusual increase in the price of oats has materially influenced the cost per pound of gain with the heavy oat consuming trials.

GROWTH RATES

The rate of growth of the different groups may be noted from data presented in Table 5. This table gives the average weights of both male and female turkeys at the end of each 4-week period to 24 weeks of age, and the results to 26 weeks are also included.

MORTALITY

The mortality for 1944 would be considered as low. Out of 317 turkeys started on these trials, 307 were included in the final results. Of the 10 turkeys eliminated from these trials, three were killed because of bad legs, from injury or otherwise, and one was killed because of perosis. A total of four cases of pendulous crop were noted. These recovered with treatment and all were included in the final determinations. The mortality for each pen and the weights for both male and female at 24 weeks of age are given in Table 6.

SUMMARY

Turkeys lacked finish when fed oats as the only grain with Mash 7. They were very unattractive in appearance and carried very little fat. The males were relatively low in weight, at 26 weeks of age, while the females were tied for first place in respect to average final weights.

Corn as grain for the last six weeks gave an abundance of finish to turkeys fed oats as the only grain to 20 weeks of age. Weights, however, tended to be lower than similar birds given multiple grain feeding to 20 weeks.

Wheat alone produced the most economical gains but wheat and corn produced heaviest turkeys when these grains were hopper fed from 8 to 20 weeks of age and corn was fed as the only grain to 26 weeks.

Wheat, fed alone or in combination with oats resulted in a lower consumption of mash than similar trials with corn alone or both corn and oats when fed during the first 20 weeks.

Multiple grain feeding during the growth period appear to give more satisfactory gains, and usually at lower cost, than when either corn, wheat or oats are fed as single grains. Corn alone, however, may be the best grain during the final weeks.

Mash 19, which contains 35 percent of soybean oil meal, gave efficient results in one year's trial with two pens of turkeys.

ETHNIC SETTLEMENTS IN RURAL MICHIGAN

By J. F. THADEN
SECTION OF SOCIOLOGY AND ANTHROPOLOGY

"IT TAKES all kinds of people to make the world" is an oft repeated expression. Michigan seems to have its proportionate share of most ethnic "kinds of people" to match its diversity of climate, soils, agricultural crops, and industrial and economic activities. The heterogeneity of our population is, in part, the result of our great variety of physical and natural resources and possibilities for growing many different kinds of crops.

Michigan is a state of numerous and diverse ethnic settlements. This tendency prevails in the rural as well as in the urban areas. It is only natural that large numbers of North American and European immigrants to Michigan tend to settle in close proximity to their fellow countrymen, near those with similar traditions, customs, language, and religion.

Two decades ago, 1920, every other person in Michigan was still a foreigner or the son or daughter of one. They comprised 52.6 percent of the total population. In the counties of Chippewa, Ontonagon, Baraga, Marquette, Iron, Houghton, Dickinson, Keweenaw, and Gogebic—all in upper Michigan, three-fourths to nine-tenths of all residents were foreign-born and immediate descendants.

Immigration restrictions during the 1920's and deaths among the older immigrants resulted in the percentage of foreign-born white stock, that is, foreign-born and native-born of foreign or mixed parentage, dropping to 47.2 by 1930. The percentage ranged from 12.0 in Hillsdale County to 82.9 in Keweenaw County, as indicated in Fig. 1. Mackinac County was the only upper Michigan county in which less than one-half of the population were foreign-born stock. The heavy influx of Canadians for many decades into the counties bordering on Lake Huron is reflected in the high percentage of foreign stock in those counties.

The native-born of foreign or mixed parentage are usually two or three times as numerous in a county as those who immigrated. For example, in Iron County, one-fourth (25.9 percent) are foreign-born

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Fig. 1. Percentage of population foreign-born white and native-born of foreign or mixed parentage, by counties: 1930.

and one-half (51.4 percent) are children of immigrants. Similar ratios prevailed in Gogebic, Ontonagon, Houghton, and Keweenaw counties. In some of the early settled areas, where the old American stock predominate, as in Hillsdale County, the percentage of foreign-born al-

though low, 2.1 percent, the children of foreign parentage still comprise a tenth of the population.

Continued immigration restriction during the 1930's, accentuated by the depression, in conjunction with the deaths of the older migrants from foreign countries caused the foreign-born stock to drop to 38.3 percent by 1940. That is, Michigan has a population of 5,256,106 (1940 census), of whom 2,010,350 are classified as foreign population stock. Even the 38.3 percent is a higher figure than in all but eight states, which are Rhode Island, Connecticut, Massachusetts, New York, North Dakota, New Jersey, Minnesota and New Hampshire. However, no state with as great a population as Michigan, except New York, has a larger foreign and first-generation population. In this connection, Wisconsin should be mentioned which, with three-fifths the population of Michigan, has exactly the same percentage of foreign population stock as this state.

MICHIGAN, AMERICA'S MIXING BOWL

Michigan is a state of Hollanders, Finns, Canadians, Belgians, Bulgarians, Poles, Syrians, Scotch, Hungarians, Yugoslavs, Rumanians, English, Germans, Greeks, Lithuanians, and Swedes. That is, in proportion to population, these ethnic groups are numerous in the state. Of the 372,384 Hollanders and people of Dutch parentage in the United States, nearly one-fourth reside in Michigan, principally in Ottawa, Kent, Kalamazoo and Allegan counties. Over one-fifth of the 284,290 Finns and people of Finnish parentage in the United States, live in Michigan, principally in the western half of upper Michigan. Over one-fifth of the Canadians and those of Canadian parentage in this country reside in Michigan, particularly in the eastern tiers of counties along Lake Huron. More than one-sixth of the 130,354 Belgians and persons of Belgian parentage reside in Michigan and a tenth of the 2,905,859 Poles and those of Polish parentage live within the state. Relatively large proportions of numerous other ethnic stocks also make Michigan their home.

Michigan has been and is more of a "melting pot" of peoples of diverse national origins than most states. It has more Belgians and those of Belgian parentage, of Finns and people of Finnish parentage, and Hollanders and persons of Holland parentage than any other state. Massachusetts is the only state having more Canadians and persons of Canadian parentage. Only Ohio exceeds Michigan in number of Bulgarian stock. Only three states have more people of English, Polish, Syrian and Yugoslav stock; only four states have more people of Hungarian and Rumanian stock; only five states have more people of Austrian, German, and Irish (northern) stock; only six states have

more people of Greek, French, Lithuanian, Russian and Swedish stock; only seven states have more people of Latvian and Welsh stock; and only eight states have more people of Czechoslovakian, Italian and Irish Free State stock.

Seven states have a larger total population than Michigan while 40 states have a smaller number. Therefore, a comparison of Michigan with other states in regard to the ethnic composition of population is more significant when made in terms of percentage than when it is made on the quantitative basis. In proportion to total population, no state has a larger percentage of Belgians[1] or Hollanders; only one state (Minnesota) has a larger proportion of Finnish people or of Poles (Connecticut), or of Bulgarians (Montana); only three states have a larger proportion of Rumanians; only four have a larger percentage of Syrians; only five have a larger percentage of Canadians, or Hungarians; only six have a larger proportion of Scotch; only seven have a larger proportion of Yugoslavs; only eight have a larger proportion of Austrians or Lithuanians; only nine have a larger percentage of English, or Germans; only 10 have a larger percentage of Latvians; only 11 have a higher percentage of Italians; only 12 have a higher proportion of Czechoslovaks; only 14 states have a larger percentage of Mexicans; only 15 states have a larger percentage of Russians; only 16 states have a larger percentage of Norwegian, French, or Danes; and so on. Truly, Michigan has been in the midst of the "melting pot" process. Hamtramck has been referred to frequently as the "Warsaw of America," Grand Rapids and Holland as the "Rotterdam and the Amsterdam" of America. Many other places are well known for their large proportion of some foreign element.

As a rule, the native-born of foreign or mixed parentage in Michigan outnumbers the foreign-born two to one. Among the earlier migrants the ratio is nearer to 3 to 1. Among the more recent migrants the ratio is nearly 50-50, as among the Belgians, Greeks, and Rumanians.

People born in Canada and their descendants are numerous in Michigan, much more numerous than the Poles who rank second, or than the Germans who rank third in this respect. These groups are trailed by those born in England and their offspring. Italians, Hollanders, Russians, Finns, Irish, Swedes, Scotch, Austrians, Hungarians, and Czechs, each of whom total over 30,000.

FOREIGN-BORN WHITE BY URBAN AND RURAL RESIDENCE

Foreign-born in Michigan have a greater tendency to settle in cities than on farms. The urban population is comprised of foreign-born to

[1]Born in Belgium or native-born of Belgian parentage or at least 1 percent was born in Belgium. In this paragraph, same applies to all other national groups under discussion.

Fig. 2. Percent of the rural-farm population foreign-born white, by counties: 1940.

the extent of 15.3 percent as compared with 9.2 percent for the farm. Some groups, notably those coming from Syria, Greece and Italy established themselves in cities. This is also true of those from Scotland, Wales, England and Ireland who migrated to Michigan. On the other hand, some ethnic groups tend to settle on farms. In Michigan, this

tendency is particularly strong among those coming from Finland, Czechoslovakia, and Denmark, and to a lesser degree of those born in Switzerland, Sweden, Lithuania, and Netherlands.

COUNTRY OF BIRTH OF THE FOREIGN-BORN WHITE FARM POPULATION

One person out of every eleven in the farm population of Michigan is foreign-born. The percentage of the farm population that is foreign-born white ranges from 2.0 percent in Hillsdale County to 30.3 percent in Keweenaw County. In eight counties, all in upper Michigan, the foreign-born comprise one-fifth or more of the farm population. The lowest percentage in any county in upper Michigan is 12.5. In lower Michigan, the foreign-born in the farm population comprise over 10 percent in 16 counties. The percentages are shown in Fig. 2. The proportion of farms operated by foreign-born is considerably higher than these figures indicate since a larger proportion of heads of families are foreign-born than of their children.

Of the 78,714 foreign-born white in the rural-farm population of the state, Canadians are the most numerous, and they comprise the principal foreign-born in 32 counties. Canadians are especially prevalent in the eastern half of the state. Numerically, German-born rank second in the farm population, and are the ranking foreign-born in the farm population of nine counties. Those born in Poland are slightly less numerous than the German-born but they are the leading foreign-born in 13 counties. The Finns constitute the principal foreign-born in 12 counties, all except Manistee being in upper Michigan. Of the foreign-born in the farm population, the Hollanders are the most prevalent in eight counties, the Swedes and Czechoslovaks in three each, the Lithuanians in two, and the Danes in one. The foreign-born, by country of birth, who comprise 10 percent or more of the total foreign-born in the rural-farm population within each county are shown in Fig. 3. In Houghton County, the Finns represent 83 percent of the foreign-born in the farm population, 78 percent in Baraga and Ontonagon counties. Holland-born constitute 54 percent of the foreign-born in the farm population of Missaukee County and 53 percent in Ottawa and 49 percent in Kent County. Czechoslovaks comprise 43 percent of the foreign-born in the farm population of Shiawassee County, 36 percent in Gratiot County.

Table 1 presents the number of foreign-born white, ranked according to numerical predominance, by country of birth, in the rural-farm population of the state and the percentage that each represents of the total foreign-born residing on farms.

Fig. 3. Forcign-born white, by country of birth, who comprise ten percent or more of the total foreign-born in the rural-farm population, by counties: 1940.

FOREIGN-BORN BY TOWNSHIPS

In 298 of the 1,265 townships in Michigan, the foreign-born comprise 10 to 19 percent of the total population. In 62 townships they comprise 20 percent or more of the total population. Foreign-born are numerous in many townships of upper Michigan, 134 of the 157 townships having at least a tenth of their population in this category. In lower Michigan, the townships with a tenth or more of their population born in foreign countries are numerous in the county of Berrien,

TABLE 1 — *Foreign-born white, by country of birth, for the rural-farm population of Michigan: 1940.**

Country of birth	Number	Percent	Country of birth	Number	Percent
Canada	14,709	18.69	Lithuania	1,520	1.90
Germany	10,073	12.80	Belgium	1,487	1.89
Poland	9,900	12.59	Denmark	1,204	1.53
Finland	7,789	9.90	Italy	1,127	1.43
Netherlands	4,399	5.59	Norway	907	1.15
Czechslovakia	4,029	5.12	Ireland	757	.96
Sweden	3,417	4.34	Scotland	748	.95
Hungary	3,406	4.33	Rumania	675	.86
Russia (USSR)	3,152	4.00	Mexico	560	.71
Austria	2,946	3.74	Switzerland	422	.54
England	2,798	3.55	France	309	.39
Yugoslavia	1,558	1.98	All others	822	1.04
Total				78,714	100.00

*U. S. Census data specially transcribed for this study.

with many Germans, Russians and Poles; in Mason County, with many Lithuanians, Poles, Germans and Danes; in Bay County, with many Poles, Germans, Canadians, and Austrians; in Saginaw County, with many Germans, Czechs, Canadians, and Poles; in Huron County, with many Canadians, Germans, and Poles; in Sanilac County, with many Canadians and Poles; and in the fringe of townships surrounding Detroit.

DELINEATION OF ETHNIC SETTLEMENTS IN RURAL MICHIGAN

In 1933, the statement was made that "There are at least 180 rural localities which are settled entirely or predominantly by immigrants."[2] Field surveys were undertaken in the winter and spring of 1945 to verify and check on these 180 "Little Hollands," "Little Finlands," etc., and to delineate other racial and ethnic settlements. This was done by a rather close study of each of the 1,265 townships of the state by means of interviews with local people who were more or less familiar with farm families and their nationality origins. The field work of delineation was done largely through personal interviews with county officials. This was supplemented by interviews with numerous township officials and community leaders and extensive correspondence. Form CA, "The Census Field Sheet and Family Record," in the offices of County School Commissioners were examined for several hundred school districts located in various counties. This form gives the country of birth of parents having children of school age. Most school districts cover an area of 4 square miles and comprise about 23 families.

[2]J. F. Thaden, *Population Trends in Michigan*, Michigan Agricultural Experiment Station, Special Bulletin 236, Page 6.

These family record forms were occasionally used to supplement information secured through interviews that proved inadequate when comparisons were made with data specially transcribed by the United States Bureau of the Census on foreign-born white, by country of birth, by counties, for the rural-farm population.

No locality was delineated as an ethnic settlement unless it had at least 10 farm families, a majority of whom (heads of families) were foreign-born or children of a foreign-born parent or parents. The few exceptions to this were relatively large settlements of second- and third-generation immigrants where language, religion, intermarriage, and other culture traits made them distinct "culture islands". The delineation of ethnic settlements is about as accurate as is possible without a house-to-house survey and the use of farm ownership plat maps.

Twenty-seven kinds of ethnic settlements were delineated. German settlements are the most numerous, a total of 86. This is followed by Polish with 65 settlements; Finnish 46; Swedish 44; mixed 44; Canadian 32; Negro 25; Irish 22; Hollander 21; Indian 19; Czechoslovak 15; French 14; Russian 13; Belgian 9; Scotch 8; Norwegian 8; Hungarian 7; Danish 6; English 5; Italian 5; Lithuanian 4; Mexican 3; Austrian 2; and Latvian, Swiss, and Yugoslav one each.

One or more ethnic settlements exist in the rural areas of 78 of the 83 counties. As many as 30 ethnic groups are present in Berrien and Chippewa counties. There are 27 ethnic groups in St. Clair County; 26 in Menominee County; 23 in Bay County; 17 in Delta County; 14 in Leelanau County; 13 in Marquette County; 12 in Macomb and Allegan counties; and a less number in the other counties.

There are 12 different types of ethnic groups in Menominee County, namely, Belgian, Canadian, Finnish, French, German, Hungarian, Indian, Irish, Latvian, Mixed, Polish, and Swedish. Eight different types of settlements are in Berrien, Delta, Leelanau, and Marquette counties; and fewer than seven different types of settlements in the other counties.

Outside of these ethnic settlements, counties are classified into five categories, namely, mixed population with no group predominant, 33 counties; mixed population with Canadians predominant, 20 counties; mixed population with Hollanders predominant, 3 counties; mixed population with Finns predominant, 8 counties; predominantly of old American stock, 18 counties; and one county (Oakland) with no group predominant in some townships and Canadians predominant in other townships. A classification on a township basis rather than on a county basis would have been more accurate and satisfactory, but it would have involved much more time and money in field work.

Much interest is manifest these days in "intercultural education". Rural Michigan could serve as a convenient laboratory for the study

of "Little Europes," of little nations within a nation, for studies of traits and characteristics of transplanted Europeans.

This delineation of the ethnic settlements should prove useful to those engaged in rural social organization. The township, in the past, has been customarily used as a convenient unit of local organization by leaders in the Farm Bureau and the Grange. Such units may be satisfactory when the population is homogeneous but in this state about one-half of the townships are quite heterogeneous in the ethnic composition of its population.

THE EFFECT OF 2,4-D ON SOME MICROORGANISMS

By RALPH W. LEWIS and CHARLES L. HAMNER
SECTIONS OF BOTANY AND HORTICULTURE

THE WIDESPREAD use of 2,4-dichlorophenoxyacetic acid as a weed killer makes it desirable to know more about its effect upon all kinds of organisms. Because most of the 2,4-D which is sprayed ultimately reaches the soil, it is especially desirable to know what effect it may have on the useful and harmful microorganisms of the soil.

Stevenson and Mitchell (1) have shown that 0.02 percent 2,4-dichlorophenoxyacetic acid or its sodium salt in potato dextrose agar had a decidedly retarding effect on four different bacteria and 0.08 percent had no apparent effect on three different fungi. Martin (2) has shown that the roots of citrus seedlings are injured when the concentrations of 2,4-D exceeds 4 p.p.m. of soil on a dry weight basis. He concludes that 2,4-D leaches quite readily from the soil and that it is destroyed slowly in the soil by the action of microorganisms. He also states that: "In small concentrations (below 10 p.p.m.) 2,4-D did not appreciably affect soil bacteria and fungi. In large concentrations (100 p.p.m. and above) some microbes were inhibited while others were not influenced. The 2,4-D was more toxic to soil microbes under acid than under alkaline conditions. At neutral reaction common soil fungi were unaffected by 2,4-D while in acid medium growth was inhibited by the same concentrations (0.1 and 1.0 percent) of the hormone."

The present work was carried out to enlarge the knowledge of the effect of 2,4-D on soil and other microorganisms and to determine if impurities might be the cause of the inhibitions observed by others.

The testing was done following the method of Vincent and Vincent (3). Filter paper discs were dipped in the solutions to be tested, placed on seeded plates, the plates incubated at 28° C., and the zone of inhibition surrounding the pads were measured after 1 or 2 days of incubation. The bacteria were grown on nutrient agar at pH 6.8; the fungi were grown on malt agar at pH 5.5.

Five different samples of 2,4-dichlorophenoxyacetic acid were tested. 2,4-dichlorophenol was also tested because it is the most common con-

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TABLE 1.—*The effect of 2,4-D and a common contaminant, 2,4-dichlorophenol, on the growth of microorganisms.*

Compounds and concentrations tested	Test organisms									
	Alternaria solani	Sclerotinia sclerotiorum	Fusarium lycopersicum	Penicillium expansum	Escherichia coli	Staphylococcus aureus	Phytomonas phaseoli	Bacillus brevis	Rhizobium leguminosarum	Bacillus subtilis
A P (1) Saturated	0	——	0	0	0	0	0	14(2)	0	0
A P 1000 ppm	0	——	0	0	0	0	0	0	0	0
A T Saturated	——	——	0	0	——	0	0	14	0	0
A T 1000 ppm	——	——	0	0	0	0	0	0	0	0
D P Saturated	0	——	0	0	——	0	14	0	0	0
D P 1000 ppm	0	——	0	0	0	0	0	0	0	0
D T Saturated	0	——	0	0	0	tr	14	16	0	0
D T 1000 ppm	0	——	0	0	0	0	0	0	0	0
D F Saturated	——	——	——	——	0	0	15	0	0	0
D F 1000 ppm	0	0	0	0	0	0	0	0	0	0
P Saturated	(3)	(3)	(3)	(3)	50	26	(3)	60	50	29
P 1000 ppm	0	0	0	0	0	0	0	0	0	0

(1) See text for names and type of chemical tested.
(2) Numbers in all columns of the table are total diameter of zones of inhibition in mm. This includes the diameter of the pad which is 12.7 mm.
(3) Complete inhibition of growth of the organism.

taminant of 2,4-D. The American Chemical Paint Co. supplied a purified 2,4-D (AP) and technical 2,4-D (AT). The Dow Chemical Co. supplied the following lots of 2,4-D: purified powder (DP), technical powder (DT) and technical flake (DF). They also supplied 2,4-dichlorophenol (P).

A summary of the tests is given in Table 1. The figures are averages of several trials. *E. coli* and *Staph. aureus* were also included because they are standard test organisms. They were incubated at 37° C. instead of at 28° C. as used for the other organisms.

The most outstanding result is the complete lack of inhibitions at a concentration of 1,000 p.p.m. It should be kept in mind that the pH of the medium was not as low as that used by Martin and that in this method of testing the 2,4-D is diluted further as it diffuses out of the

pad into the agar. Only two of the organisms, *P. phaseoli* and *B. brevis*, the first a plant pathogene, the second a soil saprophyte, are even slightly inhibited by a saturated solution of some of the 2,4-D samples. *Rhizobium leguminosarum,* one of the nitrogen-fixing bacteria, is not affected by any of the 2,4-D samples, even at the stronger concentrations.

The small amounts of impurities present in the different samples are apparently negligible in their influence on most of the microorganisms. Because some of the samples inhibit *P. phaseoli* and *B. brevis* and some do not, it must be reasoned that there is a variation from sample to sample. It is likely that this variation is due to the presence of contaminating substances. The contaminant causing this inhibition, however, is not 2,4-dichlorophenol. According to the manufacturer impurities are less than one percent. A saturated solution of 2,4-D contains less than 4,000 p.p.m. of 2,4-D thus could have as a maximum only 0.004 percent impurities. It has been shown that 1,000 p.p.m. (a 0.1-percent solution) of 2,4-dichlorophenol has no effect on any of the microorganisms and therefore cannot be the impurity causing the inhibition of *P. phaseoli* and *B. brevis.*

It can be concluded tentatively from the data available that under normal rates of application for the killing of weeds the amount of 2,4-D which reaches the soil will have no important effect on the soil microorganisms or on plant pathogenes present in the soil.

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MICHIGAN-GROWN SOYBEANS, NAVY BEANS, AND WHEAT AS SOURCES OF IRON

By THELMA PORTER[1]
SECTION OF HOME ECONOMICS

IN CONNECTION with studies on the nutritional value of farm crops grown in Michigan, the availability of the iron in navy beans, soybeans, and wheat was investigated. Previous tests which have been made on these same types of foods in other laboratories show variable results. Navy beans, as assayed by Ascham, Spiers, and Maddox (1939) using the biological method, showed 94 percent availability of the iron. Tests on soybeans have been made biologically by Sheets and Ward (1940), in which they placed the percentage of availability at 96. Using a chemical determination employing a,á dipyridyl, they found that the ionogenic iron of soybeans was 90 percent of the total, while Yang and Dju (1939) concluded that it was 88 percent.

Wheat, assayed by the biological method of Elvehjem, Hart and Sherman (1933) was found to have about 50 percent of its total iron content available. Vahltiech, Rose and MacLeod (1936), Smith and Otis (1937), and Free and Bing (1940), all using the biological assay, concluded that the iron of wheat was either nearly or actually 100 percent available. By means of chemical determinations, using a,á dipyridyl, however, Elvehjem, Hart and Sherman (1933) found that the iron of wheat was about 50 percent available, while Smith and Otis (1937) placed it at 92 percent available, and Free and Bing (1940) at 81 percent available.

EXPERIMENTAL PROCEDURE

In this study, cooked navy beans of two types, namely, Michelite and Cranberry, were studied as dietary sources of iron, along with two types of soybeans, Manchu and Cayuga, and two samples of wheat, American Banner and Red Rock. All of these products were grown on Michigan State College plots and were obtained from the Farm Crops department.

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Preparation of Foods for Analysis and Feeding

The two samples of navy beans were washed twice in tap water and once with distilled water; then they were cooked to a tender stage according to procedure A as recommended by Kelly and Porter (1941). Both beans and cooking water were placed in large porcelain evaporating dishes, covered with four layers of gauze, and dried to a constant weight at 70° to 75° C. The dried samples were ground in porcelain mortars, sifted through cheesecloth and stored in glass bottles with plastic screw caps at room temperature.

The raw wheats and soybeans likewise were thoroughly washed, dried to a constant weight, ground and stored. Great care was taken to avoid contamination with extraneous iron throughout the preparation of the food samples.

Biological Assays

The biological utilization of the iron in the six foods was determined by measuring hemoglobin regeneration and iron storage in albino rats made anemic with a milk diet. The milk was obtained directly in an enamel pail from one cow. This raw milk was transported to the laboratory in glass bottles, and fed *ad libitum* to the mothers of 2-week-old litters. It was available to the young rats as soon as they were able to reach it. Each day, for about 2 hours, the mothers were removed to separate cages containing cups of stock diet. In this way, the young were prevented from obtaining any solid food and were rapidly depleted of iron.

When the animals were 24 to 26 days old, and the hemoglobin levels were 4 gm. or less per 100 ml. of blood, the animals were placed in individual cages with screen floors of one-half inch mesh. Supplements were fed daily and, after the supplements had been completely consumed, raw milk was supplied *ad libitum*. Daily milk consumptions were recorded for each animal.

A negative control animal from each litter was sacrificed when the hemoglobin level was 4 gm. or less per 100 ml. of blood; a positive control animal in each litter was fed a daily supplement of 0.05 or 0.1 mg. iron as $FeCl_3$, 0.05 mg. copper as $CuSo_4$, and 0.05 mg. manganese as $MnCl_2$. The test animals received the foods being assayed as their source of iron and also the copper and manganese supplements. All test periods were 6 weeks, and no group of animals for a test was smaller than 18 animals representing six litters equally balanced as to sexes. When three different levels of the test food were being fed, the group consisted of 30 animals—three litters of 5 females and 3 litters of 5 males.

Hemoglobin and Total Iron Determinations on Rats

Weekly hemoglobin determinations were made on all animals by the Newcomer Method and were read in a Duboscq colorimeter. All readings were made by a single operator. To supplement the data on hemoglobin gains, the storage of iron in the carcasses of all animals was determined. Food was withheld during the 24-hour period just previous to anesthesia with chloroform. The carcasses were washed in warm soap solution, rinsed in distilled water, dried as thoroughly as possible, and put in a refrigerator overnight. The next morning, the stomachs and intestines were removed carefully, leaving as much of the mesenteric membranes in the carcasses as was possible. The carcasses were dried in individual evaporating dishes and ashed at a temperature below a dull red heat. The iron content of the ash of each carcass was determined by the thiocyanate method of Stugart (1931) as modified by Leverton (1938) on triplicate aliquots. Data on 156 animals are included in this report.

Chemical Analysis

Total iron in the dried, ground foods was determined by the thiocyanate method of triplicate portions of the dry ground samples. Considerable work was also carried out in an attempt to measure the so-called "available" or "ionogenic" iron, using the a,á dipyridyl method introduced by Hill in 1930, with various modifications of later workers including Kohler, Elvehjem, and Hart (1936), Free and Bing (1940), and Koenig and Johnson (1942).

TABLE 1—*Total and ionogenic iron in foods.*

Food	Total (1) iron (dry weight)	Ionogenic (2) iron (dry weight)	Percentage of total iron measured as ionogenic
	mg./100 gm.	mg./100 gm.	
Michelite navy beans (cooked)	7.28	0.86 — 1.26	11.8 — 17.2
Cranberry navy beans (cooked)	7.93	1.57 — 2.21	19.8 — 27.8
Manchu soybeans (raw)	10.58	0.99 — 3.39	9.3 — 32.1
Cayuga soybeans (raw)	8.85	0.24 — 1.64	2.7 — 20.7
American Banner wheat	2.99	1.38 — 1.99	46.0 — 66.5
Red Rock wheat	3.50	1.73 — 1.75	49.5 — 50.0

(1) Thiocyanate Method.
(2) a, a' dipyridyl method (with several attempts at modifications).

RESULTS AND DISCUSSION

The chemical analysis of the six foods tested are given in Table 1. The total iron determinations made by the thiocyanate method were entirely satisfactory and completely reproducible. Cooked Michelite navy beans contained 7.28 mg. of iron per 100 grams of dried ground sample; Cranberry beans 7.93 mg. The two varieties of soybeans were slightly higher in iron than the navy beans. Manchus contained 10.58 mg. of iron per 100 grams of dried ground sample, and Cayugas 8.85 mg. American Banner wheat contained 2.99 mg. and Red Rock, 3.50 mg. of iron per 100 grams of dried ground sample.

Use of the a,á dipyridyl color complex was fraught with difficulties at every step; and, as yet, this method has not been carried out in this laboratory with satisfactory results—i.e., values were not always reproducible, nor were they in line with the biological assays. They are presented at the risk of criticism in order that they may be available to investigators who might in the future attack the problem of the measurement of readily-utilizable iron by chemical means in such foods as were studied here, especially the varieties of raw and cooked beans. By way of brief explanation of the work done in this laboratory, it may be said that the following lines of attack were applied to the problem.

(1) Extraction was carried out with sodium acetate-acetic acid buffer solution at pH 5.0 or with 10-percent trichloracetic acid.

(2) Reduction of iron to the ferrous condition was accomplished with iron-free sodium hydrosulfite or sulfur dioxide.

(3) Removal of soluble proteins or other extracted substances was brought about by use of 95 percent ethyl alcohol or 7.5 percent lead acetate solution.

(4) Clarification of extracts by centrifuging and or filtering.

(5) Development of the color-complex a,á dipyridyl before or after removal of the solids from the extract.

(6) Evaluation of color intensity in comparator or in a spectrophotometer.

The chief difficulties encountered were (a) the retention of the color complex by the solid phase of the system; (b) the development of turbidity which, at the pH for maximum color development, interfered with transmission in the spectrophotometric readings and led to variable results in the comparator; and (c) lack of reproducibility of results.

It is recognized that cooking and drying the samples may have led to some changes in the foods which, in turn, caused the discrepancies between chemical and biological assay methods. It is possible also that the solubilities and physical nature of the proteins in these particular foods (beans) may be factors which led to their observed behavior with a,á dipyridyl method. Limited knowledge of the character of iron compounds present in plant tissues makes it uncertain as to whether the few reagents employed in these trials were the most satisfactory ones which could be found. Such variables as temperature, order of adding reagents, and effects of drying need further study.

Results of the measurement of ionogenic iron in the wheat samples, ranging from 46.0 to 66.5 percent, conformed closely with those of Elvehjem, Hart and Sherman (1933) but were lower than those of some investigators. Results of the chemical determinations of iron in beans tend to be considerably lower than those reported by other workers and were not comparable with the biological assays of iron in these same samples of beans. Along with some other workers (Nakamura and Mitchell, 1943; McCance, 1939) the writer is dubious of the validity of the basic assumption that the non-hematin, non-ionizable iron is also entirely non-available.

Biological Data

The biological assays of the availability of iron in the test foods were made by comparing the increases in grams of hemoglobin per 100 ml. of blood and the storages of iron in the bodies of the experimental animals with similar data from animals fed ferric chloride.

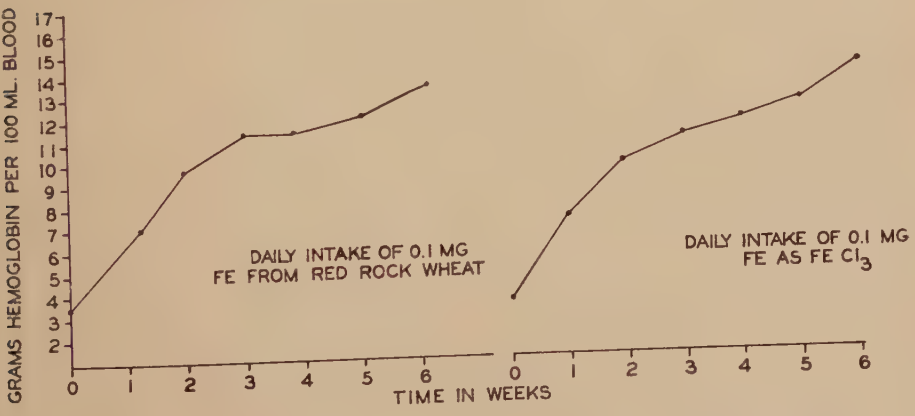

FIG. 1. TYPICAL CURVES SHOWING GAINS IN HEMOGLOBIN OF GROUPS OF SIX ANIMALS FED 0.1 MG FE DAILY FOR SIX WEEKS.

Thus the utilization of the inorganic compound, $FeCl_3$, is assumed to be 100 percent.

On the basis of hemoglobin increments in a standard 6-week test on anemic rats, Table 2 shows that, when ferric chloride and the food being assayed were fed at levels furnishing approximately 0.1 mg. of iron daily, Michigan-grown wheat and navy beans were very good sources of dietary iron. These foods contained iron in such form that it was more than 85 percent available and, in the case of American Banner wheat, the utilization of iron made possible better hemoglobin regeneration by 17 percent than did ferric chloride. Typical curves of hemoglobin increases are presented in Fig. 1. The availability of iron in the soybeans was slightly lower than in navy beans and wheat. Cayuga soybeans contained iron which was 80 percent available for hemoglobin regeneration, while Manchus contained iron only 62 percent available. Such "availabilities" were still in the range which would make these varieties of soybeans good dietary sources of iron. The calculations in Table 2 were based on the quantities of iron in the supplements only. The total food intakes of the animals represented in this table were constant for each group, caloric values between average intakes in test and positive control groups varying less than 2 calories per day. Under these circumstances no consistent differences between male and female responses were observed. These

TABLE 2 — *Availability of iron in Michigan-grown foods as determined by hemoglobin increases in anemic rats in a 6-week test period based on the iron in supplements only.*

Number of rats	Daily supplement of		Hemoglobin gains in 6-week test	$FeCl_3$ [1] needed for observed hemoglobin gains	Percentage of [2] available iron
	Food	Fe (in food)			
		mg.	gm./100 ml. blood	mg.	
6	Red Rock wheat	0.105	9.86	0.091	87
6	American Banner wheat	0.089	12.03	0.105	117
6	Michelite navy beans (cooked)	0.109	10.60	0.098	90
6	Cranberry navy beans (cooked)	0.119	9.24	0.111	93
6	Manchu soybeans	0.106	10.99	0.065	62
6	Cayuga soybeans	0.089	10.81	0.073	80

[1] Each calculation in this column is based on the average response of 6 litter-mate control rats fed $FeCl_3$ at the daily level equivalent to 0.1 mg. Fe for the varieties of wheat and navy beans, and equivalent to 0.05 mg. Fe for the varieties of soybeans.

[2] Calculated on the basis of grams of hemoglobin gained per 100 ml. of blood per weight-unit of iron fed daily in the test food.

TABLE 3 — *Average hemoglobin gains per 100 ml. of blood of anemic rats fed graduated levels of test foods.*

Wheat						Navy beans (cooked)					
Red Rock			American Banner			Michelite			Cranberry		
Daily supplement	Iron in daily supplement	Hb.-gain in 6 weeks	Daily supplement	Iron in daily supplement	Hb.-gain in 6 weeks	Daily supplement	Iron in daily supplement	Hb.-gain in 6 weeks	Daily supplement	Iron in daily supplement	Hb.-gain in 6 weeks
gm.	mg.	gm.	gm.	mg.	gm.	gm.	mg.	gm.	gm.	mg.	gm.
1.5	0.05	6.54	1.5	0.04	7.34	0.5	0.03	3.95	0.5	0.03	3.72
3.0	0.10	9.86	3.0	0.08	12.03	1.0	0.07	7.35	1.0	0.07	8.29
4.5	0.15	15.86	4.5	0.13	15.21	1.5	0.10	10.60	1.5	0.11	9.24

findings are in accord with the work of Nakamura and Mitchell (1943).

It may be pointed out that, as shown in Table 3, the level of iron intake was an important factor in determining the magnitude of hemoglobin increases in the 6-week period. An increase in iron intake, in every case, led to some increase in rate of hemoglobin regeneration, but the increments were not directly proportional to the increases in intake. Within the limits of the quantities of iron fed in this study, relatively more hemoglobin was regenerated on low intakes of iron than on high intakes. Such a physiological response has been observed to be characteristic of nutrient materials especially when fed to the growing animal. If the responses of the positive control animals fed ferric chloride were to be considered as 100, it appeared that the fairest comparison could be made when the food supplements furnished as nearly as possible the same quantity of iron daily as furnished from ferric chloride, as in Table 2.

Additional information on the availability of iron in the foods studied was obtained from the analyses of the carcasses of the experimental animals at the termination of the 6-week test. The results of this part of the study are presented in Table 4 and show that the total intake of iron in all groups of animals was between 4 and 5 mg. in the 6-week period. Initial body iron was calculated from the average body iron of six litter-mate negative controls in each group, sacrificed at the beginning of the supplemental feeding period when hemoglobin levels were 4 mg. or less per 100 ml. of blood. Variations among the groups of negative control animals were not great, ranging from about 0.7-1.1 mg. of iron, but confirmed the necessity of carrying along with each group of test animals the proper controls.

The total storage of iron in all the animals represented in Table 4 was very constant at the level of about 2 mg. in 6 weeks. In no case were the animals able to store iron from the test foods quite as effectively as from ferric chloride. Thirty-six positive control animals contained 49 percent of the iron fed to them on a raw milk diet along with 0.1 mg. iron as ferric chloride daily. Animals fed Red Rock wheat had retained 36 percent of their total intake; those on American Banner wheat as high as 47 percent. On Michelite and Cranberry navy beans, respectively, rats stored 42 and 35 percent of their iron intakes. Soybeans furnished iron in such form that the test animals stored it at the rate of 40 percent of the intake for the Manchu variety and 47 percent of the intake for the Cayuga variety.

The relation of the ability of the positive control animals in each group to store iron from ferric chloride to the ability of the test animals to store iron from the foods being assayed is presented in the last column of Table 4, and may be interpreted as percentage utilization.

TABLE 4.—*Average availability of iron in Michigan-grown foods as determined by storage of iron in anemic rats in a 6-week test period.*

Source of iron	Number of rats	Total iron intake in 6 weeks	Initial body iron	Final body iron	Storage of iron in 6 weeks	Percentage of intake stored	Ratio of iron [1] stored from food to that stored from $FeCl_3$
		mg.	mg.	mg.	mg.		
Ferric chloride	36	4.526	0.886	3.099	2.213	49	100
Red Rock wheat	6	4.604	0.853	2.488	1.635	36	73
American Banner wheat	6	3.983	1.103	2.966	1.863	47	96
Michelite beans	6	4.876	0.683	2.722	2.039	42	86
Cranberry beans	6	5.221	0.919	2.752	1.833	35	71
Manchu soybeans	6	4.739	0.749	2.642	1.893	40	82
Cayuga soybeans	6	4.027	0.921	2.802	1.881	47	96

[1] Calculated using combined response of the 36 animals on ferric chloride. Similar calculations using the positive control groups for each experimental group are of the same order of magnitude.

These percentages verify the findings obtained on hemoglobin regeneration values, although the order of rank of availability of iron changes to some extent. As in the case of the hemoglobin increments, American Banner wheat was a slightly better source of iron than Red Rock wheat. Cooked Michelite navy beans furnished iron for storage at much the same rate as for hemoglobin building; while Cranberry beans showed a considerably lower availability as indicated by storage figures. Iron from wheat and navy beans showed a lower level of availability when measured from body-iron retention data than from hemoglobin increases. On the other hand, iron from both varieties of soybeans was more readily available for storage purposes than for hemoglobin building, as indicated in the percentages of availability in tables 4 and 2, respectively.

SUMMARY

Biological assays of the availability of iron in Michigan-grown foods ranked American Banner wheat as an excellent source of iron; Red Rock wheat, cooked Michelite and Cranberry navy beans as very good sources; and Manchu and Cayuga soybeans as good sources of iron in the diets of rats made anemic with milk. These results were based on tests employing 156 rats and on data obtained from hemoglobin increments and iron retention during a standard 6-week test period.

Results of attempts to measure available iron by the determination of ionogenic iron in the dried ground samples with a,á dipyridyl were much lower than the results from biological determinations, and were not reproducible.

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FARM BUSINESS REPORT FOR 1945

*By N. L. SMITH, C. A. BECKER, J. C. DONETH, and A. H. HAIST**
SECTION OF FARM MANAGEMENT

AN ANALYSIS of 939 farm account records kept by farmers throughout Michigan indicates that 1945 was another good farming year. Production continued high, as did prices received for farm products. This relatively infrequent combination more than offset the increased farm costs and resulted in net farm earnings that were again well above the long-time level.

The farmers keeping farm accounts upon which this report is based were somewhat above average in size and quality of business but the results are indicative of the success of Michigan farmers, as a whole, during 1945.

PRICES AND COSTS IN 1945

Average prices received by Michigan farmers in 1945 were 6 percent higher than in 1944. Price increases occurred in eggs, butterfat,

TABLE 1—*Average Michigan farm prices* for crops, livestock and livestock products for 1919, 1932, 1935-39, 1944, and 1945.*

Product		1919	1932	1935–39	1944	1945
CROPS						
Corn	Bu.	$ 1.57	$ 0.33	$ 0.69	$ 1.17	$ 1.15
Wheat	Bu.	2.15	.43	.83	1.53	1.60
Oats	Bu.	.69	.20	.35	.78	.69
Barley	Bu.	1.11	.33	.61	1.24	1.14
Potatoes	Bu.	1.17	.28	.61	1.40	1.57
Field beans	Cwt.	6.98	1.37	3.06	6.00	6.08
Alfalfa hay	Ton	28.12	8.29	10.16	18.82	20.28
Apples	Bu.	1.69	.62	.71	2.14	3.12
LIVESTOCK						
Beef cattle	Cwt.	$ 9.28	$ 3.93	$ 6.52	$ 10.60	$ 12.00
Veal calves	Cwt.	14.84	5.73	9.42	14.60	15.00
Lambs	Cwt.	13.41	4.98	8.50	13.50	13.90
Hogs	Cwt.	16.01	3.73	8.56	13.10	14.20
Milk	Cwt.	3.47	1.10	1.73	3.75**	3.74**
Butterfat	Lb.	.58	.18	.30	.60**	.65**
Wool	Lb.	.57	.10	.26	.45	.45
Eggs	Doz.	.43	.15	.21	.32	.39

*Average weighted prices for calendar year.
**Includes dairy production payments.

*The Farm Management Department of Michigan State College together with the county agricultural agents and the Michigan Agricultural Experiment Station again sponsored the extension project in farm accounting. This project has been continuous since 1929. Reports were prepared for each type-of-farming area except 13, based on farm accounts kept in each area.

Area Name
1. Corn and Livestock
2. Small Grains and Livestock
3. Southwestern Fruit and Truck Crops
4. Poultry, Dairy and Truck Crops
5. Dairy and General Farming
6. Dairy and Cash Crops
7. Dairy, Hay, and Special Crops
8. Beans, Sugar Beets, and Dairy
9. Cattle, Sheep, and Forage
10. Central Potato and Dairy
11. Northern Fruit and Dairy
12. Northern Potato and Dairy
13. General, Self-Sufficing, and Part-Time
14. Cattle, Potatoes, and Self-Sufficing
15. Cattle, Hay, and Spring Grains
16. Dairy and Potatoes
17. Potatoes, Dairy, and Part-Time

Fig. 1. Type-of-farming areas in Michigan.

hay, wheat, potatoes, apples, and in all classes of livestock (Table 1). Prices received for corn, oats, and barley in 1945 averaged lower than in 1944. The price of milk remained about the same as for a year earlier.

Most of the grain produced in Michigan is marketed through livestock so the decrease in grain prices influenced incomes on Michigan farms less than on farms in a cash grain area. The increase in prices received for meat animals, eggs and butterfat were reflected in the larger livestock income.

Prices paid for products used by Michigan farmers averaged about 2 percent higher than in 1944, and this increase showed up in the increased expenses on the farms included in this report. This does not include farm wage rates, however, which increased 7 percent over 1944.

TABLE 2—*Quantity of farm products needed in Michigan to pay $100 debt.*

Product	1919	1932	1935–39	1944	1945
CROPS					
Corn.....Bu.	64	303	145	85	87
Wheat.....Bu.	47	233	120	65	63
Potatoes.....Bu.	85	357	164	71	64
Beans.....Cwt.	14	73	33	17	16
Alfalfa hay.....Ton	3.6	12	9.9	5.3	4.9
LIVESTOCK					
Beef cattle (1000 lb.).....No.	1.1	2.5	1.5	.9	.8
Lambs (90 lb.).....No.	8.3	22.2	13.1	8.2	8.0
Hogs (200 lb.).....No.	3.1	13.3	5.8	3.8	3.5
Milk.....Cwt.	29	91	58	27*	27*
Butterfat.....Lb.	172	552	333	167*	154*
Eggs.....Doz.	233	685	474	312	256

*Includes dairy production payments.

The difference in the amount of increase between prices paid and prices received resulted in a price-cost relationship which continued to favor the farmer. As in former periods of rising prices, prices of farm products have increased more rapidly than have the costs of production. This situation can be expected to reverse itself if past experience holds true.

Indications are that Michigan farmers have been taking advantage of this period of high incomes to pay debts and prepare for more normal times. It took less farm products to pay a $100 debt in 1945 than in any year since this project was started in 1929 (Table 2).

TABLE 3—*Comparison of gross income, expenses and labor incomes on accounting farms in Michigan, 1935-39 average, and by years 1941-45.*

Item	1935–39	1941	1942	1943	1944	1945
INCOME						
Crops and AAA payments	$ 906	$ 1,300	$ 1,737	$ 1,684	$ 2,215	$ 1,948
Dairy products	910	1,347	1,605	2,054	2,562	2,782
Cattle	338	560	703	624	576	727
Hogs	224	456	648	686	622	538
Poultry and eggs	256	359	492	633	586	744
Sheep	112	144	148	122	102	102
Other	163	204	193	214	212	214
Gross income	$ 2,909	$ 4,370	$ 5,526	$ 6,017	$ 6,875	$ 7,055
EXPENSES						
Feed bought	$ 261	$ 427	$ 590	$ 910	$ 870	$ 889
Machinery	291	427	497	606	717	793
Hired labor	231	315	384	490	635	557
Crop expense	193	250	343	397	498	544
Family labor	197	230	306	390	399	386
Improvements	138	151	168	213	244	247
Taxes	74	82	82	86	96	103
Other	56	109	111	137	165	177
Total expense	$ 1,441	$ 1,991	$ 2,481	$ 3,229	$ 3,624	$ 3,696
Net farm income	$ 1,468	$ 2,379	$ 3,045	$ 2,788	$ 3,251	$ 3,359
Interest on investment at 5%	641	704	742	798	845	876
LABOR INCOME	$ 800	$ 1,675	$ 2,303	$ 1,990	$ 2,406	$ 2,483

TABLE 4—*Farm earnings on farm accounting farms in Michigan, by years, 1929-45.*

Year	Labor income	Year	Labor income
1945	$2,483	1936	$1,318
1944	2,406	1935	764
1943	1,990	1934	565
1942	2,303	1933	249
1941	1,675	1932	−595
1940	787	1931	−676
1939	780	1930	−263
1938	571	1929	585
1937	569		
17-year average	$ 912		

FARM EARNINGS

The higher prices for most products sold, along with continued high production, resulted in an average "labor income" of $2,483 for the 939 farmers included in this report. This was an increase of $77 over 1944. Labor income represents what the operator of the farm receives for his labor, management and business risks incurred during the year. It does not include credit for the products used from the farm for the family. Greater returns from livestock and livestock products accounted for the increased income.

Expenses for 1945 totaled $3,696 or 27 percent higher than the average gross income for 1935-39. This emphasizes the change that occurred in farm incomes and expenses during the war years (Table 3).

Although farm income in 1945 was the highest since this project was started in 1929, the returns from farming over a long period of time should be kept in mind before conclusions are drawn concerning the earning power of farms (Table 4).

TABLE 5—*Average capital investment per farm on 939 Michigan farms, 1945.*

Item	Capital per farm	Percent of total
REAL ESTATE	$ 5,789	33
Land	4,209	23
Improvements (less house)	471	3
Orchard		
PERSONAL PROPERTY	2,572	15
Livestock (includes horses)	2,590	15
Machinery and equipment	1,907	11
Feed, crops, and supplies		
TOTAL	$ 17,538	100

FARM INVESTMENTS

Capital investments averaged $17,538 per farm for the 939 farms included in this report (Table 5). This figure more nearly represents the long-time productive value of real estate rather than the present day selling price. Feed and livestock are inventoried at more nearly current prices. If the total investments were adjusted to current prices, approximately two-thirds of the investment would be in real estate and one-third in personal property.

VARIATION IN INDIVIDUAL FARM INCOMES

Incomes on individual farms within the same type-of-farming area, differed far more than the average income of all farms between type-of-farming areas. Although many factors influence farming that cannot be controlled by man, a great deal of this variation between farms is due to the managerial ability of the operator and to the organization and enterprises on the farm. Among the factors that the operator can control to a considerable extent are the cropping and soil management practices, the type of enterprises on the particular farm, the size of business, and the efficiency in use of power, labor, and machinery.

An analysis of some of the differences between successful and less successful farms has been published in the Farm Business Report for the particular area concerned. No attempt at such analysis is made in

TABLE 6—*Percentage distribution of labor incomes, by years 1929-45, Michigan.*

Year	Total number of farms	Farms in each labor income group		
		$0 or less	$1 to $1,000	$1,001 or more
		Percent	Percent	Percent
1945	939	6	17	77
1944	1,031	5	18	77
1943	1,097	8	24	68
1942	1,160	2	18	80
1941	1,041	5	27	68
1940	1,263	12	55	33
1939	1,346	14	54	32
1938	1,252	20	57	23
1937	1,163	22	54	24
1936	1,055	6	43	51
1935	933	13	56	31
1934	845	21	56	23
1933	795	35	55	10
1932	831	87	12	1
1931	925	83	16	1
1930	771	62	32	6
1929	427	23	52	25
17-year average	993	25	38	37

TABLE 7—*Comparison of size of farm, amount of livestock and amount of work 1935-39 average and 1941-45 by years, Michigan.*

Item	1935–39	1941	1942	1943	1944	1945
Number of farms	1,150	1,041	1,160	1,097	1,031	939
Total acres	162	175	176	185	193	195
Tillable acres	107	117	117	122	129	131
Productive animal units	20.8	26.1	25.6	27.6	27.9	26.5
Productive man work units*	432	467	464	480	506	490
Number of men	1.9	1.9	1.8	1.8	1.9	1.7
Work units per man	227	254	262	269	286	271

*Areas 3 and 11 not included.

this report; however, Table 6 shows the shift of farms from one income group to another over a period of years. This indicates that it is possible for a farm to change from a low to a high-income group or vice versa.

SIZE OF BUSINESS

The increase in size and intensity of farm operations that took place on account farms during the war slowed up considerably during 1945. Farm help continued to be scarce and farmers had grown weary under the load carried during the war years. This accompanied by the difficulty in obtaining feed along with the livestock-feed price ratio exerted a restraining influence on the size of businesses (Table 7).

CROPS

The average income from crops on Michigan account farms in 1945 was $1,948 (Table 9). Crop income includes AAA payments, crop sales, and any inventory value change of feed and crops. The 1945 income from crops was slightly lower than in 1944. Most of this decrease was due to the decrease in prices received.

Yields for most crops in 1945 were higher than in 1944. This applied to all crops except potatoes, sugar beets, mixed hay, and fruit. With the exception of peaches, the 1945 Michigan fruit crop was a failure. Truck crops were hindered by a late spring freeze and by the heavy rains in certain areas during late spring and early summer. However, prices were strong and income from marketings were above 1944.

Although there was some change in crops grown on individual farms the proportion of tillable land in each crop showed no significant changes as far as all farms were concerned.

LIVESTOCK

Income from livestock averaged $4,893 per farm compared with $4,450 in 1944 (Table 10). This increase was mainly due to the higher prices obtained for livestock and livestock products sold during the year. Average numbers of dairy cows and sows on accounting farms remained practically unchanged. Numbers of ewes and hens decreased slightly from a year earlier.

The price of purchased feed and the difficulty of obtaining certain types of feed such as protein supplements and laying mash along with less favorable feed-price ratios discouraged livestock operations on many farms. The number of productive animal units, a measure of the amount of livestock on the farm, averaged 5 percent less than in 1944.

Livestock income made up 69 percent of the gross farm income in 1945 compared with 65 percent in 1944. Sale of dairy products accounted for 57 percent of the livestock returns. Poultry and eggs contributed 15 percent, cattle 15 percent, hogs 11 percent, and sheep 2 percent.

FARM EXPENSES

Average total expenses on the 939 farms increased from $3,624 in 1944 to $3,696 in 1945. This was an increase of about 2 percent which was consistent with the 2 percent increase in the general level of prices paid by farmers.

Labor continued to be by far the highest item of expense even when the operator's labor was charged at hired wage rates (Table 11). Purchased feed was the second highest item of expense. Power and machinery ranked third followed by crop expense, improvement expense, and taxes.

Expenses would have been greater had machinery and other much needed items been available.

STATE AND AREA AVERAGES

Farm earnings vary annually according to conditions in the particular area of the state that is being studied (tables 8, 9, 10, and 11). Through continued work and study most farmers can improve the returns from their farm businesses and it is toward this end that good farm management endeavors to move.

TABLE 8—*Financial summary of 939 Michigan farms by type-of-farming areas, 1945.*

Type-of-farming areas	All farms	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17
Number of farms	939	102	75	25	49	142	44	29	104	38	75	38	69	36	25	23	65
Total acres	195	191	207	111	168	211	209	219	166	203	208	172	207	249	208	185	185
Percent of farm acres tillable	67	75	77	82	78	75	75	78	77	52	60	67	55	43	64	46	37
Tillable acres	131	147	161	91	131	160	156	170	127	105	125	115	114	108	130	86	69
Real estate (less house)	$10,469	$11,888	$10,956	$16,212	$10,236	$12,406	$12,757	$12,190	$13,218	$ 7,504	$ 8,747	$14,971	$ 6,169	$ 6,784	$ 6,409	$ 7,354	$ 5,054
Machinery and equipment	2,590	2,922	2,410	2,984	2,628	2,912	3,602	2,747	2,960	1,777	2,388	3,500	2,085	1,885	2,096	2,330	1,870
Livestock (includes horses)	2,572	3,300	2,555	1,436	2,808	3,210	3,262	3,344	2,726	2,637	2,550	1,330	1,711	1,798	1,798	2,222	1,720
Feed, crops, supplies	1,907	2,510	1,946	1,800	2,036	2,505	2,183	1,852	2,339	1,253	1,737	1,951	1,480	1,509	904	875	691
Capital investment	$17,538	$20,620	$17,867	$22,432	$17,708	$21,033	$21,204	$20,133	$21,243	$13,171	$15,422	$21,752	$11,445	$11,976	$11,117	$12,781	$ 9,335
Livestock income	$ 4,893	$ 6,133	$ 5,472	$ 2,481	$ 6,912	$ 5,880	$ 6,176	$ 5,423	$ 5,203	$ 3,714	$ 5,042	$ 2,580	$ 3,102	$ 3,042	$ 2,748	$ 4,499	$ 3,701
Crop income	1,948	2,296	1,663	6,081	1,210	1,997	2,157	1,276	2,323	400	1,478	5,796	1,549	1,249	1,112	752	898
Other income	214	277	175	151	157	229	199	216	176	126	166	487	133	244	368	189	238
Gross income	$ 7,055	$ 8,706	$ 7,310	$ 8,713	$ 8,279	$ 8,106	$ 8,532	$ 6,915	$ 7,702	$ 4,240	$ 6,686	$ 8,863	$ 4,784	$ 4,535	$ 4,228	$ 5,440	$ 4,837
Total expenses	3,696	4,243	3,953	6,157	4,683	3,827	4,665	3,728	3,662	2,070	3,689	5,110	2,658	2,324	2,328	3,036	2,718
Net farm income	$ 3,359	$ 4,463	$ 3,357	$ 2,556	$ 3,596	$ 4,279	$ 3,867	$ 3,187	$ 4,040	$ 2,170	$ 2,997	$ 3,753	$ 2,126	$ 2,211	$ 1,900	$ 2,404	$ 2,119
Less: interest at 5%	876	1,031	893	1,122	886	1,051	1,060	1,006	1,062	656	771	1,086	572	598	555	638	466
Labor income 1945	$ 2,483	$ 3,432	$ 2,464	$ 1,434	$ 2,710	$ 3,228	$ 2,807	$ 2,181	$ 2,978	$ 1,514	$ 2,226	$ 2,667	$ 1,554	$ 1,613	$ 1,345	$ 1,766	$ 1,653
Labor income 1944	2,406	2,719	1,452	3,536	2,409	2,496	2,712	2,753	2,940	1,815	2,393	5,831	1,819	1,613	1,661	1,850	1,551
Labor income 1943	1,990	2,235	2,473	4,475	2,101	2,222	2,378	1,502	2,272	929	1,704	3,590	1,380	1,098	670	1,683	1,080
Labor income 1942	2,303	3,056	2,389	2,637	2,142	2,763	2,856	2,673	2,543	1,636	2,330	2,806	1,489	1,253	1,346	1,601	1,193

TABLE 9—*Kind of crops and percentage of tillable land in different crops and also yields by type-of-farming areas in Michigan, 1945.*

Type-of-farming areas	All farms	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17
Number of farms	939	102	75	25	49	142	44	29	104	38	75	38	69	36	25	23	65
Number of tillable acres	131	147	161	91	131	160	156	170	127	105	125	115	114	108	130	86	69
Percent in sod crops	43	34	41	19	38	37	46	49	31	50	51	41	56	63	64	61	67
Percent in legumes	—	27	27	—	28	28	28	33	27	35	36	—	36	46	37	41	48
Percent tillable acres in:																	
Tillable pasture	17	13	20	8	14	16	23	22	12	16	21	15	24	24	18	16	11
Alfalfa hay	12	13	12	9	11	11	12	11	7	10	15	8	13	19	3	7	6
Other hay	14	9	9	5	13	10	11	16	12	24	14	12	19	18	43	38	50
Corn (includes corn silage)	17	27	22	16	23	22	15	8	16	14	16	11	14	4	1	10	1
Wheat	9	12	14	3	12	15	7	8	10	6	4	3	2	3	3	2	1
Oats and oat mixtures	14	16	12	8	17	13	14	15	14	12	14	8	11	8	13	16	14
Barley	2	1	—	—	1	1	2	2	4	1	—	—	1	4	2	3	5
Beans	2	—	—	—	—	3	3	5	12	4	2	—	—	—	—	—	—
Sugar beets	1	—	—	—	—	—	—	3	6	—	—	—	—	—	—	—	—
Potatoes	2	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Fruit and truck	3	—	—	43	3	—	4	—	—	—	4	1	7	5	—	4	6
Other crops	7	9	11	8	6	9	8	10	7	13	10	6	9	15	17	4	6
Crop yields per acre:																	
Alfalfa hay	2.0	2.1	1.8	2.0	2.3	2.1	2.1	2.0	2.3	2.0	1.9	1.8	1.5	1.7	1.5	2.0	2.0
Other hay	1.6	1.5	1.5	1.8	1.8	1.7	2.2	1.8	1.7	1.7	1.7	1.4	1.3	1.6	1.5	1.7	1.7
Corn for silage	7.6	10.6	7.5	9.9	7.4	7.6	6.2	5.9	9.1	6.0	6.3	8.8	7.6	5.7	5.0	7.6	6.3
Corn (shelled)	42	50	41	45	39	44	36	26	38	29	32	34	23	23	—	—	—
Wheat	30	29	26	29	28	31	34	36	34	32	33	29	29	33	22	33	18
Oats	43	44	37	37	46	45	44	41	54	41	38	47	29	41	27	52	37
Barley	31	30	—	—	28	28	30	27	36	34	—	—	28	34	—	40	29
Beans	15	—	—	—	—	14	12	6	16	11	17	—	—	—	16	—	—
Potatoes	160	—	—	—	—	—	132	—	—	—	167	146	173	159	—	162	222
Sugar beets	8	—	—	—	—	—	—	5	9	—	—	—	—	—	—	—	—
Crop yield index*	100	108	91	103	102	103	100	96	112	96	95	92	80	92	84	109	101
Crop sales and AAA payments	$ 1,726	$ 1,707	$ 1,190	$ 6,770	$ 1,043	$ 1,583	$ 2,004	$ 1,296	$ 2,328	$ 596	$ 1,577	$ 6,473	$ 1,598	$ 1,428	$ 1,121	$ 571	$ 718
Crop income, total	1,948	2,296	1,663	6,081	1,210	1,997	2,157	1,276	2,323	400	1,478	5,796	1,549	1,249	1,112	752	898
Feed bought	889	1,331	1,193	767	1,647	922	802	805	819	397	989	482	518	384	460	758	747

*Area indexes based on state yields equaling 100.

TABLE 10—*Livestock: Kinds, amounts, and returns from livestock by type-of-farming areas in Michigan, 1945.*

Type-of-farming areas	All farms	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17
Number of farms	939	102	75	25	49	142	44	29	104	38	75	38	69	36	25	23	65
Livestock income, total	$ 4,893	$ 6,133	$ 5,472	$ 2,481	$ 6,912	$ 5,880	$ 6,176	$ 5,423	$ 5,203	$ 3,714	$ 5,042	$ 2,580	$ 3,102	$ 3,042	$ 2,748	$ 4,499	$ 3,701
Livestock income per tillable A.*	37	42	34	48	53	37	40	32	41	35	40	34	27	28	21	52	54
Productive animal units	26	34	32	12	29	31	29	31	26	27	25	14	21	23	17	24	20
Tillable acres per PAU**	4.9	4.2	5.0	4.6	4.5	5.1	5.4	5.5	5.0	3.9	5.0	5.3	5.5	4.8	7.5	3.6	3.4
Cattle:																	
Number of dairy cows	12.3	11.0	11.7	5.9	14.6	13.2	15.8	15.8	11.9	10.7	13.8	8.0	11.4	11.2	10.2	15.6	13.8
Dairy sales per cow	$ 226	$ 245	$ 227	$ 258	$ 250	$ 253	$ 280	$ 251	$ 235	$ 149	$ 219	$ 182	$ 167	$ 156	$ 162	$ 228	$ 216
Dairy sales, total	2,782	2,692	2,663	1,526	3,656	3,333	4,417	3,922	2,792	1,595	2,981	1,452	1,892	1,742	1,652	3,557	2,974
Cattle income	727	829	702	273	574	810	902	1,159	861	1,145	768	505	559	683	385	582	410
Hogs:																	
Number of sows	1.5	3.1	3.3	.4	1.0	2.1	.6	.3	1.7	1.5	1.0	.6	1.1	.7	.2	.1	.1
Number of litters farrowed	2.5	5.6	5.2	.6	1.8	3.5	.9	.4	3.0	2.1	1.7	.9	1.7	1.4	.2	.2	.2
Pigs weaned per litter	6.5	6.3	7.4	7.4	6.3	6.1	7.8	6.9	6.5	5.8	7.0	7.4	7.1	6.1	6.8	6.5	8.0
Hog income, total	$ 538	$ 1,292	$ 1,226	$ 180	$ 377	$ 741	$ 169	$ 56	$ 659	$ 508	$ 304	$ 195	$ 263	$ 162	$ 21	$ 6	$ 19
Sheep:																	
Number of ewes	6	10	7	0	3	14	10	4	5	9	3	0	1	11	5	1	0
Lambs raised per 100 ewes	96	92	105	–	91	94	116	86	106	75	96	–	68	100	95	91	–
Sheep income, total	$ 102	$ 193	$ 112	$ 0	$ 35	$ 236	$ 86	$ 41	$ 100	$ 141	$ 47	$ 0	$ 11	$ 153	$ 77	$ 14	$ 0
Poultry:																	
Number of hens	106	136	106	88	321	102	101	60	127	61	118	60	51	55	91	72	47
Egg sales per hen	$ 4.86	$ 4.92	$ 4.96	$ 5.21	$ 5.63	$ 4.86	$ 4.63	$ 3.54	$ 4.30	$ 3.97	$ 5.30	$ 5.30	$ 3.57	$ 3.92	$ 5.40	$ 4.52	$ 4.58
Egg sales, total	515	669	526	460	1,807	494	468	211	548	240	627	317	182	216	490	324	213
Poultry income, total	744	1,127	769	502	2,270	760	602	245	791	325	942	428	377	302	613	340	298

*TA—Tillable acres. **PAU—Productive animal units.

TABLE 11—*Expense and efficiency factors: Labor, machinery, improvements, and other costs by type-of-farming areas in Michigan, 1945.*

Type-of-farming areas	All farms	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17
Number of farms	939	102	75	25	49	142	44	29	104	38	75	38	69	36	25	23	65
Gross income per tillable acre	$ 54.37	$ 59.77	$ 45.45	$ 95.85	$ 63.43	$ 50.65	$ 54.55	$ 40.77	$ 60.73	$ 40.30	$ 53.44	$ 77.00	$ 42.18	$ 41.94	$ 32.46	$ 63.25	$ 70.42
Total expenses per tillable acre	36.40	36.69	31.63	80.10	44.50	31.09	36.84	28.32	37.53	28.52	38.12	53.15	31.25	30.28	24.97	46.29	51.90
Total expenses*	4,756	5,389	5,102	7,283	5,809	4,975	5,763	4,802	4,786	3,000	4,770	6,086	3,552	3,274	3,254	3,981	3,570
Man labor:																	
Number of men	1.7	1.7	1.6	2.3	1.9	1.7	2.2	1.8	1.7	1.5	1.7	2.2	1.6	1.8	1.6	1.7	1.8
Work units per man	271	335	324	—	302	331	253	297	289	257	286	—	257	376	222	251	206
Hired labor	$ 557	$ 516	$ 503	$ 1,966	$ 645	$ 432	$ 1,229	$ 563	$ 400	$ 124	$ 498	$ 1,427	$ 446	$ 374	$ 339	$ 472	$ 291
Family labor	386	348	304	208	456	406	397	481	414	389	382	407	306	374	311	324	550
Operator's labor	1,060	1,146	1,149	1,126	1,126	1,148	1,098	1,074	1,124	930	1,081	976	894	950	926	945	852
Man labor cost per tillable acre	15.33	13.68	12.13	36.30	17.06	12.41	17.41	12.57	15.20	13.72	15.67	24.55	14.48	15.70	12.09	20.24	24.62
Power and machinery:																	
Percent without horses	31	46	41	36	18	30	20	24	38	21	21	50	19	33	8	21	42
Investments	$ 2,590	$ 2,922	$ 2,410	$ 2,984	$ 2,628	$ 2,912	$ 3,002	$ 2,747	$ 2,960	$ 1,777	$ 2,388	$ 3,500	$ 2,085	$ 1,885	$ 2,007	$ 2,330	$ 1,870
Annual expense	793	811	788	1,034	788	848	910	837	943	571	784	1,061	646	555	615	704	576
Expense per tillable acre	6.08	5.52	4.89	11.37	6.04	5.30	5.82	4.93	7.40	5.42	6.26	9.26	5.68	5.13	4.72	8.18	8.37
Improvements:																	
Investment (less house)	$ 4,209	$ 5,039	$ 4,372	$ 4,564	$ 4,293	$ 5,066	$ 5,056	$ 4,770	$ 5,373	$ 2,923	$ 3,823	$ 4,793	$ 2,585	$ 2,817	$ 2,353	$ 3,198	$ 2,384
Investment per animal unit	159	143	136	353	141	162	174	145	200	103	143	334	116	117	121	126	114
Annual expense	247	281	262	329	261	310	285	250	312	157	231	257	167	188	144	178	133
Expense per tillable acre	1.91	1.91	1.62	3.62	2.00	1.93	1.82	1.47	2.45	1.48	1.84	2.24	1.46	1.74	1.11	2.07	1.93
Feed bought, total	$ 889	$ 1,331	$ 1,193	$ 767	$ 1,647	$ 922	$ 802	$ 805	$ 819	$ 397	$ 989	$ 482	$ 518	$ 384	$ 460	$ 758	$ 747
Per tillable acre	6.80	9.06	7.39	8.43	12.62	5.76	5.13	4.75	6.42	3.78	7.91	4.21	4.56	3.55	3.53	8.82	10.85
Crop expense, total	$ 544	$ 627	$ 591	$ 1,540	$ 535	$ 572	$ 669	$ 466	$ 464	$ 251	$ 531	$ 1,184	$ 397	$ 268	$ 287	$ 386	$ 279
Per tillable acre	4.14	4.27	3.66	16.94	4.10	3.57	4.28	2.75	3.64	2.39	4.25	10.34	3.51	2.48	2.20	4.49	4.05
Taxes, total	$ 103	$ 132	$ 118	$ 100	$ 120	$ 137	$ 133	$ 120	$ 118	$ 70	$ 85	$ 104	$ 65	$ 60	$ 57	$ 71	$ 38
Per tillable acre	0.78	0.92	0.73	1.10	0.92	0.86	0.85	0.71	0.93	0.67	0.67	0.91	0.57	0.56	0.44	0.83	0.56
Other expense, total	$ 177	$ 197	$ 194	$ 213	$ 231	$ 200	$ 240	$ 206	$ 192	$ 111	$ 189	$ 188	$ 113	$ 121	$ 115	$ 143	$ 104
Per tillable acre	1.36	1.33	1.21	2.34	1.76	1.26	1.53	1.14	1.49	1.06	1.52	1.64	.99	1.12	.88	1.66	1.52

*Includes operator's labor.

RESISTANCE OF MICHIGAN HONEY ROCK No. 55 TO FUSARIUM WILT: A PROGRESS REPORT

By D. M. McLEAN
SECTION OF BOTANY

FUSARIUM WILT of muskmelons was first observed in Michigan in 1940 in a large commercial planting of the Heart of Gold variety in Berrien County. It is likely that the disease has been present in the state for a much longer period of time, but its identity was not determined. Although the disease is not widely distributed in the state, it is slowly spreading, and in time probably will be found wherever muskmelons are grown commercially. Under conditions of heavy soil infestation,

Fig. 1. Michigan Honey Rock No. 55 melon showing small seed cavity, thick flesh, and good uniform netting.

ARTICLE 29-16

the disease may cause 90 percent or more loss of the crop, and under ordinary conditions of soil infestation 20 to 50 percent loss of stand may result.

The disease was reported first from New York in 1930. In 1931, it was described as being very destructive to muskmelons in Minnesota. The records of the Division of Mycology and Plant Disease Survey of the United States Department of Agriculture contain reports of muskmelon wilt attributed to Fusarium spp. from the following states: Alabama, Arizona, Arkansas, Michigan, Mississippi, Missouri, New Jersey, New Mexico, New York, North Carolina, Ohio, Oregon, South Carolina, Texas and West Virginia. The disease has likewise been reported from Ontario and Vancouver Island, Canada. While it is not certain that these reports all deal with the Fusarium wilt disease under discussion, it is certain that the organism causing wilt is rather widespread.

The disease causes considerable loss wherever it occurs. Some fields in Michigan are so heavily infested that it is impossible to grow muskmelons to maturity. Several farmers have discontinued growing melons because of the discouragement resulting from poor crops often due to this disease. Others have had to rent or buy land which has never been planted to melons to escape its ravages. This involves increased costs which limit the margin of profit for a successful industry.

Because of the limited distribution of Fusarium wilt, actual losses for the state are not very great. Potentially, however, the disease is of great economic importance. The fungus may be carried long distances on or in the seed harvested from infected crops and in time general distribution is likely to occur. The disease will likely increase in severity in regions of intensive culture, and unless suitable means of control are devised greater losses may be expected in future years.

Although muskmelons are not a major crop in Michigan, they are grown rather extensively in the southern half of the state, especially in Berrien, Wayne and Bay counties. The melons are grown principally for local consumption, although much of the crop is crated and hauled by truck to the markets of larger cities and to adjoining states. They are grown chiefly on light sandy loam soil that warms up quickly in the spring and maintains a relatively high soil temperature throughout the summer.

Table 1 taken from the Crop Report for Michigan, January-February 1945, shows the average acreage, yield, production, and value of the market muskmelons for a ten-year average from 1934 to 1944. Data for 1945-46 are likewise included. As indicated in the table, since 1940 the muskmelon acreage has decreased nearly 50 percent in Michigan, likewise, yield per acre of marketable melons has dropped nearly 50

TABLE 1—*Showing acreage, yield, production, and value of the muskmelon crop for the past 13 years. Table taken from "Crop Report for Michigan, January-February, 1945."*

Crop year	Acreage harvested	Average yield per acre*	Production	Average price received by growers	Total value	Average value per acre
	acres	*crates*	*1,000 crates*	*dollars*	*1,000 dollars*	*dollars*
1934	4,800	90	432	1.15	497	104
1935	4,900	145	710	.80	568	116
1936	4,900	115	564	1.10	620	126
1937	4,700	110	517	1.25	646	138
1938	5,300	120	636	1.00	636	120
1939	5,300	120	636	.90	572	108
1940	5,000	90	450	1.40	630	126
1941	4,800	120	576	1.50	864	180
1942	4,200	105	441	2.10	926	220
1943	2,500	85	212	4.00	848	340
1944	2,800	90	252(1)	3.45	821(1)	293(1)
1945	2,800	70	196	3.40	666	238
1946	3,000	85	255	—	—	—
Averages—1934-1943	4,640	110	517	1.52	681	158

*Standard crates of approximately 60 pounds.
(1)14,000 not marketed and excluded in computing value.

percent. In 1943, muskmelon harvest overlapped somewhat with a large peach harvest. Shortage of help and lowered values of the crop due to poor quality caused many growers to leave the remaining melon crop in the field to harvest peaches.

Michigan formerly ranked among the leading states in muskmelon production. The crop represents a very important source of income particularly in the areas where the fruit industry, especially peaches, is concentrated. Melons are usually placed on the market before peach harvest and at a time when the southern and western supplies are dwindling; at this time they generally demand a fair price. In recent years, owing to diseases, labor shortage, poor seasons and increased cost of production many commercial growers have discontinued melon culture. The crop is still a very important source of income to the truck farmers of the state.

Recently, a rather general practice of irrigating muskmelons has developed. The overhead system of irrigation is the most common type in use. During seasons of prolonged deficiency of rainfall the water is applied usually at the rate of about one inch per week. Barnyard manure is used extensively and is usually supplemented with commercial fertilizers applied at the rate of about 500 pounds per acre of a 3-12-12 or 3-9-18 formula.

The most commonly grown varieties are the Honey Rock and the Heart of Gold. Formerly, the Heart of Gold was grown almost exclu-

sively in Berrien County, while in Wayne County the Honey Rock variety has gained greater favor. Honey Rock in general, is now more commonly grown and has gained such popularity because of its earliness and excellent quality.

Previously, diseases have not been very important as limiting factors in melon culture in Michigan. The disease most likely to cause defoliation or leaf blight is caused by the fungus, *Alternaria cucumerina*. Anthracnose, caused by *Colletotrichum lagenarium*, is sometimes prevalent when rainfall in late summer is unusually abundant. Most commercial growers practice a rigorous spray program for control of these diseases in Michigan. Occasionally plants are affected with bacterial wilt caused by *Erwinia tracheiphila*, and mosaic sometimes causes relatively slight losses.

Since many growers apparently do not understand the nature and cause of the wilt disease and often confuse it with bacterial wilt, alternaria blight or anthracnose, a brief review of the principal characteristics of the wilt follows.

SYMPTOMS OF THE DISEASE

The fungus causing wilt was described in 1938 in Minnesota, after it was isolated from infected plants, as *Fusarium bulbigenum* var. *niveum* f2. The fungus closely resembles the pathogen which causes a similar wilt disease in watermelons. However, the organisms are not the same since the fungus which causes wilt in muskmelons seems to be specific to muskmelons and will not cause wilt in watermelons. Likewise, the fungus causing wilt in watermelons does not cause wilt of muskmelons. It belongs to a group of closely related fungi which cause wilt diseases in such crops as asters, cabbage, cotton, mint, flax, celery and tomatoes. The organism apparently is able to persist in the soil indefinitely, regardless of whether melons are grown on the land, and there is no practical means of soil treatment which will rid the soil of it. When it becomes established in the soil the fungus multiplies by spores until the field must be abandoned for muskmelon production or a resistant variety which will tolerate the Fusarium fungus must be grown.

The fungus may be introduced into new fields in a number of ways. Seeds harvested from infected melons may carry the fungus and, when planted, such infected seeds will introduce the fungus into clean soil. More common and general means by which new areas may become infested are the transportation of soil and plant materials from infested fields by water, the transportation of the fungus in soil carried on cultivating implements and on the feet of men and animals.

Fig. 2. Muskmelon Fusarium wilt showing the general field symptoms which precede death of the infected plants.

The fungus may infect muskmelon plants in any stage of their development. In heavily infested soil, usually at low temperatures, seedlings may be destroyed before they emerge above ground. After appearing above ground, affected seedlings may damp-off. On older seedlings, particularly in cool soils, necrotic lesions may appear on the hypocotyl at the soil line or below ground sometimes causing root necrosis and death of the infected plant. Seedlings may wilt without apparent evidence of infection. In commercial fields where the infestation usually is light, wilting does not occur to any great extent often until the vines are well grown, and at this stage the effects of the disease are very conspicuous and disheartening (Fig. 2). Wilted plants may revive somewhat overnight, but the recovery is only temporary and usually within a few days the plant dies.

The first symptom on older plants is nearly always a wilting of one or more runners (Fig. 2). This may be confused with bacterial wilt, however, blackish necrotic lesions usually are apparent on the stem near the ground line (Fig. 3). These lesions may involve the entire stem and extend down into one or more of the rootlets or only one side of the stem may be infected, the lesion extending for some distance as a long, brown streak from which numerous droplets of a reddish resinous appearing exudate may be observed (Fig. 3). Wilted plants sooner or later die.

Fig. 3. Muskmelon Fusarium infection showing necrotic lesions on the stem with a resinous exudate from the lesions.

During periods of high moisture, necrotic lesions may be covered with salmon-pink masses of spores of the fruiting pathogen. In this condition the fungus is easily disseminated by wind, water and other agencies.

The infection does not particularly cause a browning or necrosis of the vascular elements, although this is sometimes observed in advanced stages of infection. The initial infection seems to occur in the cortical tissues. Often the cortex of the stem is completely necrotic while the vascular bundles show no evidence of infection. The black necrotic lesion on the roots and stem, particularly at the ground level, has caused certain farmers to refer to the disease as "black root".

The fungus is most destructive in cooler soils and in early-planted melons. Muskmelons are relatively resistant in soils at temperatures of 30° C. (86° F.) or higher. The pathogen is destructive in infested soils at temperatures below 27° C. (80° F.) and grows very little below 6° C. (43° F.) and above 37° C. (99° F.). Muskmelons grow best with soil temperatures at 30° to 35° C. (86-95° F.). Melon seeds do not germinate well at temperatures below 18° C. (64° F.).

In view of the foregoing facts, sprays or dusts are valueless in controlling the disease, and it is apparent that the most feasible and economic means of combating it is the development of and use of varieties or strains of muskmelons that are resistant or tolerant to the fungus.

Workers at the University of Minnesota early began to search for a resistant muskmelon suitable for commercial use. They found considerable resistance in such types as Honey Dew, Casaba and similar melons, but these matured too late in Minnesota and were otherwise unsatisfactory. From selections of a natural cross, apparently between Honey Dew and Bender's Surprise, the Minnesota workers found melons which were resistant and at the same time of a desirable type. Through their efforts the variety Golden Gopher was developed. Many other crosses and selections were made and seeds from certain of their best types were generously supplied to workers at other stations. Workers at the University of Cornell, by utilizing these Fusarium resistant parents, developed the variety Iroquois which has gained rapid popularity in New York state. None of these Fusarium resistant types have met the demands of the Michigan growers and work is in progress at the Michigan Agricultural Experiment Station to develop a Fusarium resistant melon which will meet the demands of our local farmers.

DEVELOPMENT OF MICHIGAN HONEY ROCK No. 55

The methods of selection and cross-breeding disease susceptible plants with disease resistant plants has given satisfactory control of Fusarium wilt diseases in such crops as tomato, flax, cabbage, celery, watermelon and other crops.

In 1941, a program was initiated at the Michigan Agricultural Experiment Station for the purpose of controlling Fusarium wilt and Alternaria blight in muskmelons in Michigan.[1] A great number of seed samples from exotic types of melons received from Afghanistan and Turkistan were supplied by the United States Department of Agriculture. Many of these were discarded without further trial, however, some resembled the Casaba types and showed some resistance to Fusarium in field tests. Seeds from Fusarium-resistant selections were generously supplied by the Minnesota workers. All commercial varieties when tested on Fusarium-infested soil were very susceptible to wilt and seldom produced a marketable melon. Open-pollinated selections were made from healthy plants in a commercial planting of the Heart of Gold variety where many of the plants were killed by Fusarium.

[1]This project is supported by Federal funds on a Bankhead-Jones 1-F allotment.

Numerous cross-pollinations were made between certain non-resistant commercial types and the resistant parents for the purpose of obtaining resistance to the disease in the more desirable commercial types suitable for Michigan. The progeny from these hybrid melons were then tested in the field under conditions of heavy soil inoculation. In making these field tests, the plants are grown in field soil which has grown muskmelons successively for a number of years. The soil is inoculated each season by placing the Fusarium fungus growing on sterilized wheat or oats in contact with the roots of the plants at the time they are set in the field.

Certain selections from these crosses show considerable resistance to Fusarium and have been inbred a number of generations. Only a few are suitable for commercial trial in Michigan.

In the winter of 1943, a cross was made between a Fusarium-resistant parent, Minnesota 10-38, and an excellent strain of a commercial Honey Rock variety obtained from a grower in Michigan. Melons from the Minnesota parent are rather prominently ribbed, medium sized, not well netted and the flesh is deep orange, firm, fine textured and of excellent quality. The Honey Rock melon is not prominently ribbed, has a very heavy coarse netting, uniform in size and shape and has a thick, rather coarse textured, bright orange flesh. When tested in the field during the summer of 1944, the first generation hybrid was 90 percent or more resistant to Fusarium. A self-pollinated selection was made from a resistant plant of the F_1 progeny which closely resembled the Honey Rock parent. This was again crossed with Honey Rock (back-cross) in the greenhouse during the winter of 1944-45. The back-cross progeny were again tested in heavily infested soil in the summer of 1945. Only self-pollinated selections from resistant plants were saved from this generation. These were again self-pollinated in the greenhouse during the winter of 1945-46. The self-pollinated lines are uniform enough that in the 1946 field tests they have been planted in such a manner that open-pollinated selections within the different lines may be made. The different lines will be kept separate until there are no apparent differences in size, shape and other desirable qualities. Finally, selections may be made from open-pollinated resistant plants in a group planting. This selection procedure has three principal objectives: (1) to select for high degrees of resistance; (2) to combine resistance with other desirable characters; and (3) to fix these characteristics so that the selections will breed true.

This melon has been given an arbitrary number of 55 in the breeding records.

Fig. 4. General view of the 1946 experimental field on the experiment station farm, showing uniform stand of Michigan Honey Rock No. 55 on soil that has produced six successive crops of melons under very heavy Fusarium inoculation. (Photographed August 13.)

The melon has been tested with several commercial growers on infested soil and has shown upwards from 75 percent resistance to Fusarium wilt.[2] Fig. 4 shows a general view of the 1946 experimental field on the experiment station farm. This field had grown muskmelons successively for the six preceding years with a heavy inoculation of the Fusarium fungus each year. Commercial types of melons have shown nearly complete destruction when planted in this soil.

The melon promises to be superior to most commercial strains of Honey Rock. In addition to selecting for Fusarium resistance, good size, netting and quality have received particular attention. The flesh is fine textured with a deep orange color. Its quality is generally superior to that of commercial Honey Rocks. Foliage is darker green, leaves are slightly larger and the plant in general is more vigorous than most Honey Rocks.

Seeds of the melon are not yet available for large-scale commercial trials. Several more generations of selecting are needed to obtain the desired uniformity in size and shape.

[2]The writer wishes to acknowledge the assistance and support of the growers who are cooperating in the experimental trials.

Progress likewise is being made in developing resistance to Alternaria blight. A Hales Best type of muskmelon from Indiana, which has been introduced from Purdue University as Purdue No. 44, has shown a high degree of resistance to this disease. Michigan Honey Rock No. 55 has been crossed to Purdue No. 44 and certain of the resulting progeny show some resistance to both Alternaria blight and Fusarium wilt.

CLOSED MICHIGAN RURAL SCHOOLS

By J. F. THADEN and EUGENE B. ELLIOTT[1]
SECTION OF SOCIOLOGY AND ANTHROPOLOGY

HUNDREDS of "little red schools" in Michigan are closed. With shrinking size of families, more than a thousand rural schools in the state seem to have grown "too little," or "too costly," or "too unsatisfactory" in other respects for their education-minded citizens. In 1944, there were 5,008 primary school districts, which usually have only a one-room, one-teacher school. In 1,189—more than one-fifth—of all the primary districts, school electors at their annual election in July, or at some special meeting, voted to close their schools and instructed their school boards to arrange for educational facilities in some other district, usually in some graded district with about one teacher per grade. However, the district with the closed school continues as before, as a quasi-corporate institution, with its customary independence and local autonomy. Each year the electors of these closed districts must vote to determine the course to be followed. Often they continue to remain closed year after year. Sometimes the people vote to remain partly open (possibly six or seven grades), or again they frequently decide to annex themselves to the larger district, in which case they lose their district identity.

In more than 500 other primary school districts, the school electors in 1944 voted to close the eighth or both seventh and eighth grades. Furthermore, in 17 graded and township districts, schools were voted closed by their constituents.

This process of closing schools but retaining school district identity, has been going on for years. Closed schools numbered 181 in 1923, 372 in 1930, 737 in 1942, and 1,206 in 1944-45. These included a few graded and township school districts. The present teacher shortage is not the only nor the primary cause for these closings, nor has teacher shortage been the major contributory cause in past years. The war accelerated the movement. The present high wages in industry are furnishing additional momentum temporarily, by luring underpaid teachers. That education costs money, especially when the number of pupils per teacher dwindles to less than about 25, seems to be another recent discovery of some tax payers.

[1]State Superintendent of Public Instruction for Michigan.

Closed schools are associated with many measurable factors, and the reasons for closing are almost as numerous as there are people who voted to close their schools. However, an ever recurring cause, in county after county and community after community, can be attributed to helpful local educational leaders and enlightened local citizenry.

CLOSED SCHOOLS, BY COUNTIES

This report is a presentation of the closed primary school situation in 1944-45 on a state-wide basis, showing variation by counties, popula-

TABLE 1—*Number of primary school districts and number and percentage of schools in primary districts closed, 1944-45.*

County	Primary School Districts			County	Primary School Districts		
	Number	Closed	Percent		Number	Closed	Percent
Alcona	24	13	54	Lenawee	168	40	24
Alger	0	—	—	Livingston	115	24	21
Allegan	131	22	17	Luce	0	—	—
Alpena	1	0	0	Mackinac	0	—	—
Antrim	25	12	48	Macomb	81	10	12
Arenac	21	5	24	Manistee	29	11	38
Baraga	0	—	—	Marquette	0	0	—
Barry	86	36	42	Mason	43	11	26
Bay	67	3	4	Mecosta	52	32	62
Benzie	26	12	46	Menominee	25	7	28
Berrien	107	14	13	Midland	65	8	12
Branch	117	40	34	Missaukee	19	9	47
Calhoun	116	20	17	Monroe	131	7	5
Cass	94	21	22	Montcalm	91	18	20
Charlevoix	24	12	50	Montmorency	0	—	—
Cheboygan	36	10	28	Muskegon	65	8	12
Chippewa	2	1	50	Newaygo	98	34	35
Clare	35	13	37	Oakland	108	21	19
Clinton	107	24	22	Oceana	76	9	12
Crawford	4	2	50	Ogemaw	36	10	28
Delta	0	—	—	Ontonagon	0	—	—
Dickinson	0	—	—	Osceola	64	19	30
Eaton	124	51	41	Oscoda	3	3	100
Emmet	42	19	45	Otsego	10	1	10
Genesee	102	7	7	Ottawa	102	10	10
Gladwin	26	0	0	Presque Isle	21	2	10
Gogebic	0	—	—	Roscommon	8	5	63
Grand Traverse	47	9	19	Saginaw	115	28	24
Gratiot	111	21	19	St. Clair	127	13	10
Hillsdale	121	48	40	St. Joseph	110	42	38
Houghton	10	9	90	Sanilac	113	21	19
Huron	87	14	16	Schoolcraft	0	—	—
Ingham	96	11	11	Shiawassee	103	14	14
Ionia	119	37	31	Tuscola	137	28	20
Iosco	15	7	47	Van Buren	130	55	42
Iron	0	—	—	Washtenaw	136	24	18
Isabella	77	23	30	Wayne	51	4	8
Jackson	102	18	18	Wexford	38	17	45
Kalamazoo	90	31	34				
Kalkaska	32	13	41				
Kent	166	32	19				
Keweenaw	0	—	—				
Lake	17	10	59	Michigan	5,008	1,189	23
Lapeer	110	14	13				
Leelanau	21	10	48				

tion density, soil fertility, type of farming, land values and farm income; giving a comparison of certain characteristics between closed and open schools in Missaukee and Barry counties for 1945-46; and summarizing the implications of these closings. The number of primary districts, by counties, and the number and percentage with schools closed, are presented in Table 1.

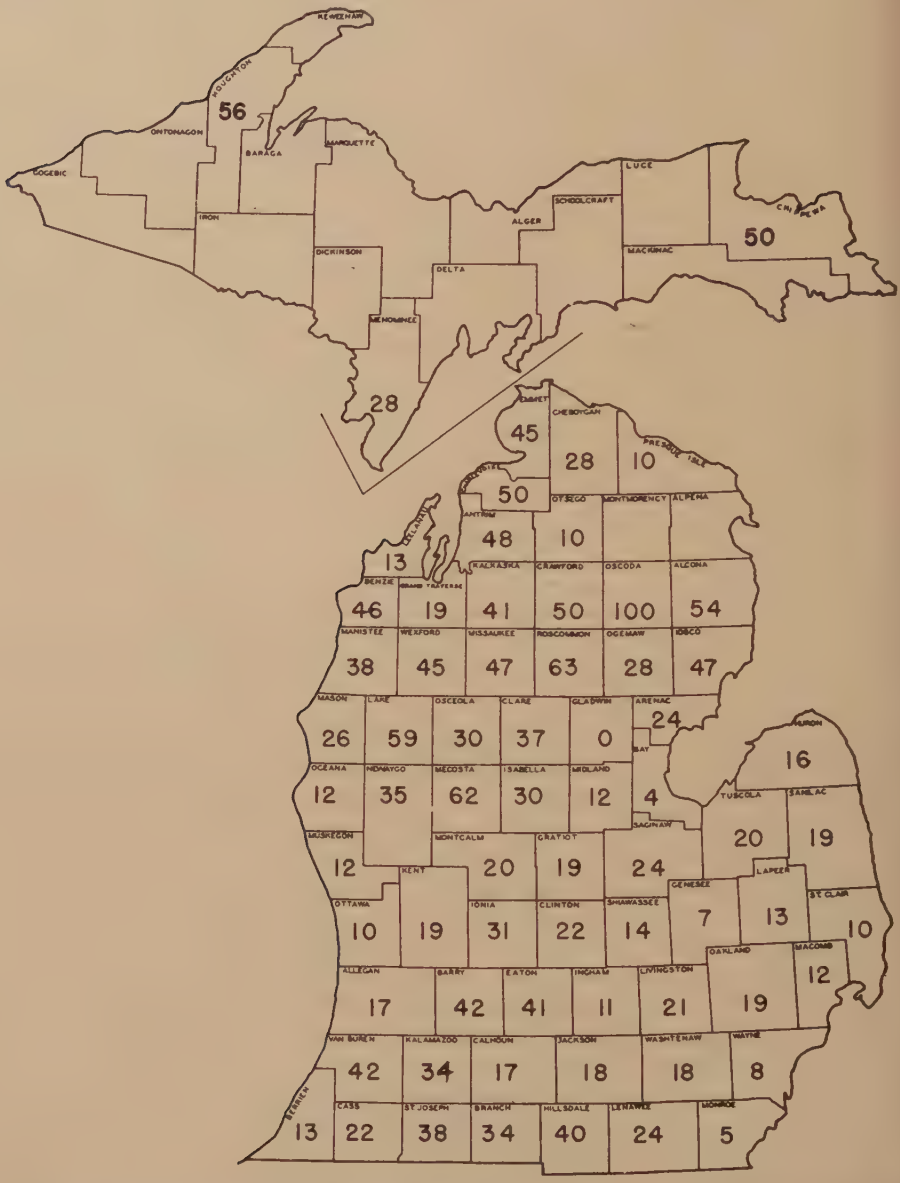
Twelve of the 15 upper peninsula counties have no primary districts. The reason is that a majority of the school districts in these counties are township districts, formed under the upper peninsula township unit act of 1891. This act gave boards of education authority to consolidate any of the schools of the township and transport the pupils to such schools. In lower Michigan, five counties have very few or no primary districts for the reason that most school districts are township school districts formed under special township acts or the general township act of 1909.

The number of primary districts varies from none in 13 counties to more than 100 in 26 counties, and as many as 166 in Kent and 168 in Lenawee.

The number of schools closed, by counties, varies considerably. The number of closed schools varies from none in Alpena and Gladwin, besides the counties with no primary districts, to more than 50 in the counties of Eaton and Van Buren.

The percentage of closed schools varies from none to 50 or more in the counties of Alcona, Charlevoix, Chippewa, Crawford, Houghton, Lake, Mecosta, Oscoda, and Roscommon, as indicated in Fig. 1. However, each of these, except Mecosta, has less than 25 primary districts remaining. consequently but a small part of the total area of each of these counties lie within primary districts. This association may be partly due to population density, since counties with few primary districts have sparse population.

On the surface, there seems to be no obvious reasons for the wide variation between counties, especially between adjacent counties, in the percentage of schools that are closed. For example, in Saginaw County, 24 percent of the primary schools are closed, and is surrounded by six counties with only 7 to 20 percent of them closed. On the other hand, Calhoun County, with 17 percent of its schools closed, is surrounded by six counties with from 18 to 42 percent closed. However, one observation is that south of the Bay City-Muskegon line are 7 counties with one-third or more of their schools closed, and north of this line are 17 such counties. This gives clues that possibly sparse population, meager fertility of soil, type of farming, low income, and low land values may create sufficient economic necessity to stretch the school tax dollar that it induces school closings. This is frequently a transition stage



NOTE: Errata—the figure in Genesee County should read 7; that in Missaukee County 47; in Leelanau County 48; and in Houghton 90.

Fig. 1. Percentage of schools in primary school districts that were closed, 1944-45.

toward school district reorganization and larger taxing units. Apparently, economic, social, cultural, and other conditions vary enough from county to county that the state average of 23 percent of schools closed could not be approximated closely in all counties.

TABLE 2—*Closed schools and farm population density.*

Number of farm people per square mile	Number of counties	Percentage of schools closed
Under 10	29	38
10 to 14	10	36
15 to 19	9	27
20 to 24	14	23
25 to 29	13	21
30 and over	8	16
Michigan	83	23

CLOSED SCHOOLS IN RELATION TO FARM POPULATION DENSITY

As farm population increases, by counties, the proportion of schools that are closed tends to decline. Such a trend is recognized in Table 2. In counties with sparse population, those having on an average less than 10 farm people per square mile, 38 percent of the schools are closed. In one of these counties, Oscoda, 100 percent are closed, in Roscommon 63 percent, Lake 59 percent, and Alcona 54 percent. However, very few primary districts remain in these counties. The percentage of closed schools is less and less in the subsequent groups of counties with increasing farm population density. Only 16 percent are closed in the eight counties with 30 or more farm people per square mile. In one of them, Bay, only 4 percent are closed, and in Monroe only 5 percent.

Fifty-nine percent of the townships of Michigan experienced a loss in population from 1920 to 1930,[2] and this undoubtedly induced many school districts to vote favorably on closing their schools. Continued declining farm population may be expected in many predominantly rural areas of the state and will probably be a contributing causal factor for a growing number of schools to close in the future.

CLOSED SCHOOLS AND AGRICULTURAL LAND

Sparse population is closely associated with limited soil fertility, so that one may attribute, in part, the closing of schools to poor soil. Veatch[3] has classified the land of Michigan, based on economic interpretation of land types in relation to present day agriculture. In lower Michigan, 8 million acres, or about one-third, and in the upper peninsula, 900,000 acres, or 8 percent, are classified as "first class" for general

[2]J. F. Thaden, *Population Trends in Michigan*, Michigan Agricultural Experiment Station, Special Bulletin 236, 1933, page 27; also *Michigan Today—Its Human and Physical Resources as They Affect Education*, Michigan State Department of Public Instruction, Bulletin 307, 1937, page 126.

[3]J. O. Veatch, *Agricultural Land Classification and Land Types of Michigan*, Michigan Agricultural Experiment Station, Special Bulletin 231 (first revision) 1941, pages 62 to 65.

TABLE 3—*Closed schools and first class agricultural land.*

Percentage of land that is first class	Number of counties	Percentage of schools closed
Under 10	26	41
10 to 24	21	26
25 to 49	21	21
50 and over	15	19
Michigan	83	23

agricultural purposes. Less satisfactory land is progressively classified as "second class," "third class," and "fourth class." In this analysis, the closed school situation will be related to "first class" land only. This relationship is indicated in Table 3.

In the 26 counties in which less than one-tenth of the land is classified as "first class," 41 percent of the schools are closed, while in the 15 counties in which one-half or more of the land is "first class," only 19 percent of the schools are closed. In Lake County, in which only 1 percent of the land falls in the category of "first class," 59 percent of the schools are closed. On the other hand, in Genesee County, in which as much as 67 percent of the land is rated high, only 7 percent of the schools are closed.

In general, the fertility of the soils is not improving as fast as it is diminishing. Soil conservation practices can greatly reduce soil losses. To the extent that declining soil fertility drives people off the land, it will have a baneful influence on the maintenance of open schools. This forecasts continued closing of schools. Even in many of the counties with high proportion of good land schools are closed in goodly numbers. For example, in Eaton, with 69 percent of its land "first class," 41 percent of the schools are closed, and in Lenawee, with 68 percent of the same superior land, 24 percent of the schools are closed.

CLOSED SCHOOLS IN RELATION TO TYPE OF FARMING

The Department of Farm Management of Michigan State College has classified the counties of the state as to principal types of farming, based on agricultural census reports. The counties of Michigan fall into 17 groups or areas,[4] as indicated in Table 4. The counties of Crawford, Oscoda, and Roscommon are in the category of "General, Self-sufficing, and Part-time Farming," in which 10 of the 15 remaining primary districts, or 67 percent, are closed. Nine-tenths, or 90 percent, of the

[4]E. B. Hill, *Types of Farming in Michigan*, Michigan Agricultural Experiment Station, Special Bulletin 206 (revised) 1939.

schools are closed in the "Potatoes, Dairy and Part-time" area of the upper peninsula, which comprises 12 counties. In the seven counties comprising the "Northern Potato and Dairy" area are 190 primary districts, of which 83, or 44 percent, are closed. The proportion of closed schools also runs high in the five counties of the "Central Potato and Dairy" area, in which 113 of the 322, or 35 percent, of the schools are closed. The five counties comprising the "Cattle, Potatoes, and Self-sufficing" area have 25 of their 81 schools closed. In general, the five above-mentioned types of farming areas, comprising 32 counties, have small percentages of fertile land and low population density, which, probably more than type of farming, are among the more basic causes for the closing of schools. Marginal farming areas compel efficient school district organization and school closings in order to get the most from the school tax dollar. In wealthy communities people can afford to be less economical and thrifty with their school budget.

The lowest percentage of closed schools occurs in the "Dairy, Hay and Special Crops" area comprising Sanilac and St. Clair counties, and in the "Dairy and Cash Crops" area of Lapeer, Macomb, Oakland, and Wayne counties. In these six counties, only 83 of the 540 schools, or 14 percent, are closed. Good land and population density run high in these areas. About one-third as many schools are closed in the two last-mentioned areas as in the "Northern Potato and Dairy" area.

Type of farming, in and of itself, probably has little direct influence

TABLE 4—*Closed schools in relation to type-of-farming areas.*

Type-of-farming area*	Number of counties	Percentage of schools closed
General, self-sufficing and part-time	3	67
Potato, dairy, and part-time	12	90
Cattle, hay, and spring grains	2	50
Northern potato and dairy	7	44
Central potato and dairy	5	35
Cattle, potatoes, and self-sufficing	5	31
Small grains and livestock	5	30
Southwest fruit and truck crops	2	29
Dairy and potatoes	1	28
Cattle, sheep, and forage	5	26
Corn and livestock	4	25
Northern fruit and dairy	6	24
Dairy and general farming	9	21
Beans, sugar beets, and dairy	7	19
Poultry, dairy, and truck crops	4	16
Dairy and cash crops	4	14
Dairy, hay and special crops	2	14
Michigan	83	23

*E. B. Hill, *Types of Farming in Michigan*, Michigan Agricultural Experiment Station, Special Bulletin 206 (revised) 1939.

on keeping schools open. Whether schools are open or closed is undoubtedly more closely related to such factors as soil fertility, population density, possibly local fiscal ability, and most certainly on capable educational leaders and child-centered citizens.

AVERAGE TOTAL FARM FAMILY INCOME AND CLOSED SCHOOLS

It costs a lot of money to operate schools. The largest part of the average farmer's tax dollar generally goes for schools. It costs more to operate a school when open than when it is closed, although most closed schools probably cost more to maintain than the average tax payer and school elector realizes.

Seemingly in areas where income from the farm combined with supplemental income is low, schools are more likely to be closed than in areas where income is more plentiful. The United States census of 1940 gives the total income per average farm, based on median value of farm products sold, traded, or used by farm household. It averaged $757 for the state of Michigan, and ranged from $184 in Keweenaw County to $1,593 in Huron County. The same census also gives the average number of days that farmers worked off farms for pay or income in 1939 by counties, and from which supplementary earnings of farmers may be estimated. These off-farm earnings averaged $89 per farm in Huron County, at one extreme, to $832 in Genesee County. The estimated average for the state was $308. When these estimated off-farm earnings are added to the median farm income, a close approximation is obtained regarding total farm income, by counties, for 1939. This figure ranges from $506 in Benzie County to $1,682 in Huron County. The state average is $1,065.

When the counties are grouped as to total farm income a gradual increase of closed schools is observed with diminishing incomes. This association is indicated in Table 5. More than twice as many schools are closed in the 15 lowest income counties as in the 13 highest income counties. In the lowest income group of $500 to $824, all counties except Van Buren, are northerly counties where soil fertility tends to be limited and distance to industrial centers with opportunities for supplementary income are considered. The counties in the highest income group, $1,260 to $1,682, in general, have lots of good land and their farmers have more favorable access to means of supplementing their incomes from the farm by working in factories. Apparently, economic necessity forces many schools to close in poverty stricken localities and abetted by strong education-minded leaders. The percentage of closed schools rises from 19 to 20. to 24, 27, 31, and to 44, as one moves successively from the highest income group to the lowest income group.

TABLE 5—*Closed schools in relation to income.*

Income group*	Number of counties	Percentage of schools closed
$500 to $824	15	44
825 to 924	15	31
925 to 984	14	27
985 to 1120	13	24
1121 to 1259	13	20
1260 to 1682	13	19
Michigan	83	23

*Figures are obtained by adding to the median value of farm products sold, traded or used by farm household the estimated average income for off-farm work.

AVERAGE VALUE OF FARM LAND AND BUILDINGS PER ACRE AND CLOSED SCHOOLS

The ability to support schools and to pay for the education of our children tends to be affected, at least indirectly, by the value of farm land and buildings. The 1940 census shows that the average value of farm land and buildings per acre ranged from $15.86 in Kalkaska County to $197.57 in Wayne County, with an average for the state of $50.59. That the decrease of closed schools is generally gradual and steady, with increased average value of farm land and buildings per acre, is indicated in Table 6. Starting with 35 and 43 percent of the schools being closed in the 28 counties with average value per acre being from $15 to $27, the percentage of closed schools gradually drops to 26, 22, and 17, in successive groups of counties with higher land values. Land values depend upon many factors but, in general, it is rather closely related to productivity and soil fertility, the normal value of land as determined by the long-time earning power of the land.

TABLE 6—*Closed schools in relation to average value of farm land and buildings per acre.*

Average value of land and buildings	Number of counties	Percentage of schools closed
$15 to $21.99	14	35
22 to 26.99	14	43
27 to 49.99	15	26
50 to 61.99	13	22
62 to 200.00	13	17
Michigan	83	23

In many instances the closing of a school precedes its annexation or merging with the district that its pupils attend. Of the approximately 700 school districts in the state which have annexed or merged with others since June 1943, at least 120 had previously closed their schools one or more years, some for as long as ten years.

COMPARISON BETWEEN CLOSED AND OPEN SCHOOLS IN MISSAUKEE COUNTY, 1945-46

In Missaukee County, six primary school districts are closed, three are partly closed, (eighth grade or both seventh and eighth), and six districts are open. Detailed comparisons among such few cases are hardly warranted. However, a few contrasts will be mentioned briefly. For the school year 1945-46 total revenue receipts averaged $625 in the closed schools and $1,873 in the open school districts. Total operating expenditures averaged $629 in the former and $1,925 in the latter. Salaries of school boards in the closed districts averaged $45.84 and in the open districts $53.58. However, salaries of school boards, when computed on the basis of school census, averaged 16½ cents in the closed schools and 12½ cents in the open districts. Expenditures for supplies and expenses of school boards averaged higher in the closed than in the open districts, $3.46 as compared with 55 cents. Expenditures for taking the school census averaged slightly higher per child in the closed than in the open schools. Closed districts were spared the expense of paying salaries to teachers, usually constituting the major part of the school budget. However, the closed schools have bills averaging $398 for transportation of pupils. Owing to smallness of the number of schools involved in these comparisons, little significance can be attributed to these differences unless similar differences are found in studies of other counties.

CLOSED SCHOOLS IN RELATION TO NEARNESS OF VILLAGES AND CITIES

A glance at a school district map of Michigan, with closed schools indicated thereon, gives one the impression that closed schools tend to cluster around village graded districts. For example, Marcellus, (population 992) and Vermontville (population 564) are surrounded completely by adjacent closed schools. Many other village graded districts are almost completely surrounded. Among them are, Camden, Central Lake, Climax, Dowagiac, Falmouth, Hersey, Kalkaska, Lawton, McBain, Mendon, Morley, Nashville, North Branch, Saranac, Stanwood, Thompsonville, Union City, Westphalia, and White Pigeon. In recent

months, around Camden, Nashville, and McBain, rural agricultural schools have been formed, and around Climax and North Branch, township school districts have been formed, so that these villages are not as completely surrounded by closed schools as they were a few years ago. This is another indication that the closing of schools, especially those adjacent to villages, is a transition stage, in many instances, to reorganization into larger taxing and administrative units and one important step in the equalization of educational opportunities.

Many closed schools of a few years ago have annexed to other districts or have merged with other districts, frequently with closed districts, usually to form a rural agricultural district, or a township district. Of the 54 school districts now comprising the 5 rural agricultural districts of Missaukee County, 24 had previously closed completely or one or more of the upper grades had been closed, before merging or annexing. The 14 which had closed completely had been closed an average of 5.3 years. In Barry County, 14 districts recently merged with or were annexed to the rural agricultural districts at Middleville, Woodland, Delton, and Nashville. These had been closed on an average of 6.6 years, some of which had previously been partly closed.

CLOSED AND OPEN SCHOOLS IN PRIMARY SCHOOL DISTRICTS OF BARRY COUNTY, 1945-46

The history of school closings in Barry County is probably typical of the trend in many other counties. In that county, in 1930-31, seven schools were closed. Some of these were annexed to other districts, and the number of closed schools dwindled to one in 1933-34. Then an average of 3 schools closed annually during the next 10 years, totaling 36 closed schools in 1944-45. Since then, the formation of the rural agricultural school at Nashville, in June 1946, and other annexations, brought the number of closed schools down to 23 at the present time.

In this connection it is interesting to note the large number and the types of primary districts served by a small city school district. For example, Hastings, the county seat of Barry County, serves 12 districts with closed schools, 22 districts with the eighth or both the seventh and eighth grades closed, and the eighth grade graduates of 14 other districts.

Comparisons of primary districts with completely closed schools with districts having all eight grades in operation, are presented for Barry County, in Table 7. The average number on the school census May 31, 1946, was 21.8 in the 26 closed schools and 34.3 in the 20 open schools. In the closed schools, the school census ranged from 4 to 73, and in the open schools from 13 to 60. It seems that smallness is an in-

TABLE 7—*Twenty-six primary school districts with completely closed schools compared with 20 primary school districts with no grades closed, Barry County, for school year 1945-46.*

	26 Closed schools	20 Open schools
Average number on school census, May 31, 1946	21.8	34.3
Average estimated value of school properties: Land	$ 111.00	$ 70.00
Buildings	348.00	1,140.00
Equipment	225.00	304.00
Average amount of fire insurance	835.00	1,560.00
Average annual premium for fire insurance	2.62	4.00
Average amount of tornado insurance	907.00	1,710.00
Average annual premium for tornado insurance	2.08	3.34
Average levy for general operating—Mills	3.1	8.1
Range of levy for general operating	0.0–8.5	5.0–23.0
Number with no levy for general operating	11	none
Average amount of tax levied for general operating	$ 175.00	$ 852.00
Average assessed valuation	89,492.00	116,102.00
Average assessed valuation per census child	4,224.00	3,385.00
Average cash balance for general operation, June 30, 1945	572.00	378.00
Average general property tax collected (current operating)	166.00	818.00
Average amount of primary money received	257.00	421.00
Average amount of state school aid received	127.00	563.00
Average total revenue receipts	578.00	1,886.00
Average grand total of receipts	634.00	1,919.00
Average salaries of board of education	32.67	43.87
Average for census and compulsory attendance expense	2.85	2.58
Average expenses for school census per census child	.13½	.07½
Average total general control expenditure	38.00	54.00
Average total expenditure for instruction	46.00	1,482.00
Average total expenditure for transportation	576.00	69.00
Average total expenditure for operating school plant	3.00	149.00
Average fixed charges: Insurance	5.00	8.00
Average total maintenance expenditures	16.00	40.00
Average total operation expenditures	722.00	1,802.00
Average grand total of cash expenditures	724.00	1,814.00

ducement to close, thus substantiating one of the introductory statements. As far as school census is concerned, there are reasons for suggesting that the large closed schools be opened, and for some of the small open schools to be closed, rather than for them to function as they are. One naturally assumes that it may be desirable and economical to close small schools but less essential to do so for districts with many children. Two of the closed schools each have a much larger school census than is the average school census of the open districts. On the other hand, there are two open schools, each with a smaller school census than the average of the closed schools. However, this is the choice of the school electors themselves. They made the decisions whether to close or not, and not some township, county, state or federal official or agency.

In Barry County, the closed schools are not appreciably nearer nor farther from the schools to which their pupils are sent than are the open schools from their preferred schools, as indicated by the school attended by their eighth-grade graduates. In the 26 closed schools the

children are transported by bus from 3 to 16 miles, an average of 7.3 miles. The school buildings in the open districts are located from 2 to 18 miles from their preferred school, an average of 7.5 miles.

A fact or two may be presented here regarding the partly closed schools. In Barry County, school electors last year voted to close the

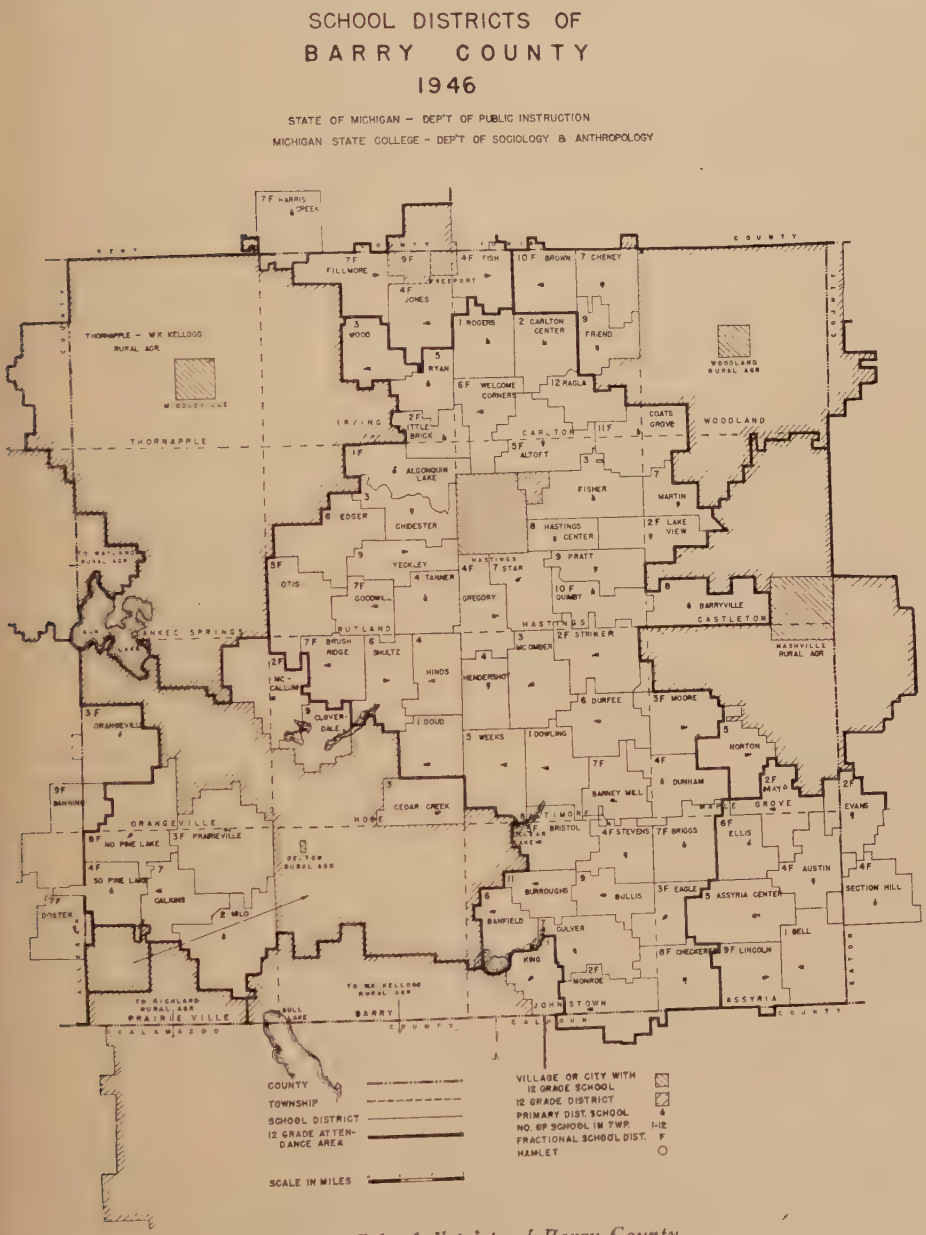


Fig. 2. School districts of Barry County.

eighth or both the seventh and eighth grades in 28 districts. The schools in these districts are located from 3 to 17 miles, or an average of 8.7 miles, from the schools to which their upper-grade pupils are sent. Financially, it is now good business to close the upper grades since the state now pays the cost of having them transported. Educationally, it is wise to close those grades, as this makes their pupils vulnerable then to the compulsory school attendance laws which require school attendance to the age of 16 years. Of possibly greatest significance in this arrangement is the integration of pupils into an educational system where their pursuance of a high school education is very greatly enhanced. After the pupils in the upper elementary grade or grades were taken from these partly closed schools, the teachers had opportunity to give more of that cherished individual instruction to the remaining pupils, which numbered 9 at the Moore and Burroughs schools (Fig. 2), 11 at Fisher, 12 at Cloverdale, 15 at Quimby and Mayo, and 16 at Hinds and Brush Ridge.

In the 20 open schools of Barry County the average enrollment in kindergarten and in each grade, averaged 2 pupils. Obviously the average enrollment in each grade in the closed schools, if they had operated, would have been less than two. No wonder the school electors voted to close. One of the most pathetic situations in these small schools that are operating is that in so many instances a pupil has no classmate, to say nothing of classmates. In five of the open schools, the kindergartner has no classmate; in six schools, the first grader has no classmate; in five schools, the second grader has no classmate; in three schools, the third grader recites alone; and in the other grades the sociological condition is equally bad or even worse. Many pupils compete only with themselves or have not the stimulus of competitive cooperation. In 44 grades of the 20 open schools, pupils find themselves at the head of their class, or the foot of their class, since they are the only person in the class. In 39 grades, pupils have only one classmate. The largest class in the 20 open schools is one of 8 pupils in the sixth grade, in the Brown school, 3½ miles east of Freeport.

The educational and social welfare of the pupils in the open schools could be improved by cooperation between districts. At present, the average teacher in the 20 open schools has 18 pupils with an average of 2 per grade. Pupils and teachers would fare better when 25 to 30 pupils distributed in one, two, or possibly three grades are brought together under the tutelage of one teacher. One-third or one-half of the teachers would thereby be eliminated and some of the funds allotted for their salaries could be used for transportation of pupils.

TRANSPORTATION AND TUITION

A total of 499 elementary school pupils and 377 high school pupils from the 58 closed and partly closed primary districts of Barry County, in 1945-46, were transported to one or another of the following school systems: Hastings, Delton, Bellevue, Freeport, Woodland, Middleville, and Martin. The tuition rate charged the non-resident elementary pupils was from nothing in four school districts to $50. Transportation charged the non-resident elementary and secondary school pupils varied greatly: from $21.10 per year by one district, $24 by two districts, $26 by one district, $36 by another district, and 14.7 cents per mile by one district. There seems to be a need for tuition rates to be harmonized with actual cost of instruction and that transportation charges be based on actual transportation costs. If this were done, the tuition and transportation charges would be quite similar for the different receiving districts.

SOME SCHOOL COSTS AND SCHOOL MILLAGE LEVIES COMPARED

Closed schools, like open schools, cost money to maintain. There is fire and tornado insurance to be paid, which averaged $4.70 for the 26 closed schools and $7.34 for the 20 open schools, in Barry County, last year. But this is a trifle compared to the salaries of its school boards. The school boards of the closed schools received an average salary of $32.67, those of the open school districts, $43.87. However, on the basis of the number of children on the school census, the school boards of the closed schools were paid $1.54 per child and those of the open districts $1.28. It is of some significance in this connection to note that the school board members of Detroit, Flint, and Grand Rapids, with nearly one-half of the children of the state, like school board members of some other districts, receive no pay or salaries for serving as members of their respective school boards.

Possibly one of the more important reasons for the closing of schools is that it seems to be good business. Many a closed school ceases to levy a school tax after closing, or levies a tax only about every other year, or levies a lower tax than formerly when it was open. The mill tax levy for school purposes in Barry County for 1945-46, averaged 3.1 in the closed schools and 8.1 in the open schools (see Table 7). In the closed schools the school levy varied from nothing to 8.5 mills. Eleven districts levy nothing. Ten other closed districts levied 1.0 to 4.5 mills, less than that of any open school, the lowest of which was 5.0 mills in the Altoft and Coats Grove districts. Four other closed districts

levied from 5.0 to 8.0 mills, all of which were less than the average millage levy of the open schools, which was 8.1. If the closed districts had levied 8.1 mills for school purposes, as did the average open district, they would have raised $19,572. Instead, they levied only $4,733, thereby saving their tax payers $14,839, or failed by about that amount of contributing their just share towards the costs of education. However, besides the primary money which every district receives from the state on the basis of the school census, only 9 of the 26 districts received state aid, amounting to $3,427; while each of the 20 open school districts received some state aid, totaling $11,269 for all 20 districts.

TAX LEVY FOR SCHOOL OPERATION IN CLOSED SCHOOL DISTRICTS

Figure 2 shows the school districts of Barry County, as of September 1, 1946. The variation in tax levies by school districts can easily be followed thereon. The Cheney district levies no school tax and has levied no such tax for at least the past 7 years. The same is true of South Pine Lake district (see Table 8).

Among the districts in which the school tax levy dropped after the school had closed, sometimes a year or so after closing, are: Eagle and Friend each dropped from 4 mills to nothing; Ragala and Edger, each from 6 mills to nothing; Gregory from 7 mills to nothing; McCallum from 7 mills to one mill; Branch from 6 mills to 4 mills; Blake[5] from 5 mills to one mill; Goodwill from 7 to 4 mills; Yackley from 6.5 to 3 mills; and Richie from 2.5 to one mill.

Among closed districts which tended to have a school levy only about every other year, are Barnum, Castleton Center, Hosmer, Pratt, and Otis. Several districts tended to have a lower than normal levy every other year or so, such as Wellman, Feightner, and Quailtrap.

The tax levy continued much the same after closing, or even rose slightly with rising school costs in some districts, such as, Bell, Austin, Ellis, Cedar Creek, Ryan, Fillmore, Yankee Springs, and Hendershot, although the levy was not high enough, 4 mills, in several districts, one or more years, to qualify them for state aid.

[5]Since the school year 1944-45, a number of districts with closed schools have become annexed to rural agricultural districts, namely, Barnum and Wellman to Woodland; Richie and Yankee Springs to Middleville; Blake to Delton; Castleton Center, Feightner, Hosmer, Morgan, Beigh, Branch, McKelvey, Maple Grove Center, and Quailtrap became merged in the Nashville reorganization.

TAX LEVIES IN OTHER PRIMARY SCHOOL DISTRICTS OF BARRY COUNTY

In most of the open school districts the tax levy is more uniform and predictable than in the closed schools, but not always, and sometimes runs abnormally high, frequently very much higher than in the average rural agricultural district. The checkered school is levying 23.0 mills, as it did the previous year, a rate 3½ times the average rate of

TABLE 8—*Millage levy in closed school districts since 1939-40.*

Township	School district No.	School district Name	Date closed	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46
Assyria	1	Bell	1936-37	*4.5*	*4.5*	*4.5*	*4.5*	*4.5*	*4.5*	*5.0*
	3f	Eagle	1941-42	7.5	7.0	*4.0*	*0.0*	*0.0*	*0.0*	*0.0*
	4f	Austin	1936-37	*5.0*	*4.0*	*4.5*	*4.5*	*4.5*	*4.5*	*4.5*
	6f	Ellis	1938-39	*3.25*	*4.0*	*4.0*	*4.5*	*4.0*	*4.5*	*4.0*
Baltimore	4	Hendershot	1944-45	7.0	6.0	6.0	7.0	7.5	*8.0*	*8.0*
Carlton	3f	Barnum (a)	1937-38	*0.0*	*3.5*	*0.0*	*2.0*	*0.0*	*2.0*	*0.0*
	7	Cheney	1937-38	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	9	Friend	1941-42	3.0	*4.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	12	Ragala	1942-43	4.0	5.0	5.0	*6.0*	*0.0*	*0.0*	*0.0*
Castleton	2	Castleton Center (a)	1940-41	7.0	*3.0*	*4.0*	*0.0*	*4.0*	*0.0*	*4.0*
	3	Hosmer (a)	1939-40	*3.0*	*3.0*	*0.0*	7.0	*4.0*	*0.0*	*2.0*
	4	Wellman (a)	1941-42	3.0	5.0	*0.0*	*1.0*	*2.0*	*1.0*	*2.0*
	5	Morgan (a)	1937-38	*0.0*	*0.0*	*2.0*	*3.0*	*2.5*	*2.0*	*0.0*
	6	Feightner (a)	1937-38	*3.0*	*2.0*	*2.0*	*2.5*	*3.0*	*2.5*	*0.0*
Hastings	4f	Gregory	1944-45	6.0	5.0	5.0	7.0	7.0	*4.0*	*0.0*
	9	Pratt	1938-39	*0.0*	*0.0*	*0.0*	*3.0*	*0.0*	*3.0*	*4.0*
Hope	2f	McCallum	1942-43	6.0	7.0	7.0	7.0	*5.0*	*1.0*	*1.0*
	3	Cedar Creek	1944-45	7.0	7.0	6.0	6.0	6.0	*6.0*	*6.0*
Irving	4f	Jones	1944-45	4.0	0.0	0.0	6.0	5.0	7.0	*2.0*
	5	Ryan	1938-39	*3.0*	*4.0*	*4.0*	*4.0*	*4.0*	*4.0*	*3.0*
	7f	Fillmore	1936-37	*5.0*	*3.0*	*4.0*	*4.0*	*5.0*	*4.0*	*4.0*
Johnstown	9	Bullis	1939-40	*4.0*	*4.0*	*4.0*	*4.0*	*4.0*	*8.0*	*7.5*
Maple Grove	1f	Quailtrap (a)	1941-42	3.5	4.5	*4.0*	*2.5*	7.0	*3.0*	*3.0*
	2	Maple Grove Center (a)	1937-38	*1.0*	*2.5*	*2.5*	*4.0*	*2.0*	*2.0*	*2.0*
	6	McKelvey (a)	1937-38	*3.0*	*3.0*	*0.0*	*2.0*	*1.0*	*2.0*	*5.0*
	7f	Branch (a)	1942-43	3.0	5.0	6.0	*4.0*	*4.0*	*4.0*	*4.0*
	8	Beigh (a)	1937-38	*4.0*	*4.5*	*4.0*	*2.0*	*2.5*	*2.5*	*0.0*
Orangeville	4	Blake (b)	1942-43	4.0	5.0	5.0	*4.0*	*1.0*	*1.0*	*1.0*
Prairieville	4f	South Pine Lake	1937-38	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	7	Calkins	1935-36	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	8f	North Pine Lake	1944-45	3.0	3.5	3.5	3.5	3.5	*4.5*	*0.0*
Rutland	5f	Otis	1937-38	*3.0*	*5.0*	*5.0*	*0.0*	*0.0*	*3.0*	*0.0*
	6	Edger	1942-43	5.0	7.5	7.5	*6.0*	*6.0*	*6.0*	*0.0*
	7f	Goodwill	1943-44	7.0	7.0	7.0	7.0	*7.0*	*4.0*	*4.0*
	9	Yeckley	1934-35	7.0	7.5	6.5	*3.0*	*4.0*	*3.0*	*4.0*
Yankee Springs	3f	Yankee Springs (c)	1945-46	4.0	5.0	6.0	7.0	7.0	7.0	*8.5*
	8	Richie (c)	1934-35	*0.0*	2.8	2.5	*1.0*	*1.0*	*0.0*	*0.0*

NOTE:—Figures in *italics* indicate that school was closed.
(a) Merged to form the Nashville Rural Agricultural, June 10, 1946.
(b) Annexed to Delton Rural Agricultural since the end of the school year 1945-46.
(c) Annexed to Thornapple—W. K. Kellogg Rural Agricultural (Middleville) at end of school year 1945-46.

the three rural agricultural school districts of Barry County. It had 2 pupils in the third grade, 2 pupils in the fourth grade, one in the seventh grade, and one in the eighth grade, with no enrollments in the other grades. The Wood school levied 17.5 mills, more than 2½ times that of the average rate of the rural agricultural schools at Middleville, Woodland, and Delton. The levy for the Thornapple-W. K. Kellogg school at Middleville was 7.5, Woodland 7.0, and Delton 5.3.

With four exceptions, Coats Grove, Martin, Altoft, and Norton, every one of the 48 districts operating their schools, although some of them with only 6 or 7 grades, are levying higher tax rates for school purposes than is the average rate of the three rural agricultural school districts. In most instances the rate is higher than would be paid if these districts were annexed to the rural agricultural districts or merged to form such a district, with elementary attendance centers at strategic locations. Under such an organization, transportation would be reduced to the minimum and hundreds of the youngsters in the lower grades would be transported only a few miles instead of 10 to 16 miles as some are at present, with every district for itself.

SUMMARY

It has been shown that the percentage of closed schools is higher in some counties than in others and that part of the tendency to close is associated with such factors as, sparse population, low agricultural potentiality, part-time farming, the raising of such crops as potatoes, small grains, and cattle, and with low income, and low land values. Yet large numbers of schools are closed in some counties that present a satisfactory picture in these respects, undoubtedly because of the strong desires of the well-informed citizenry and socially educated leaders to present their rural boys and girls with opportunities for elementary and secondary education as good as those available any where.

It was shown for Barry County that the closed schools present striking contrasts to the districts with open schools in some respects. Each of the other items in Table 7 could be diagnosed in considerable detail. Probably enough contrasts have been indicated at the moment. A school once closed, whatever the reason or reasons, rarely reopens. It eventually merges or annexes itself with another district or districts. During this transition stage it needs help, because it tends to have a parasitic existence and fails to carry its fair and full share of the cost of education. The economic tragedy is heightened when this transition stage is unnecessarily prolonged. School boards, community leaders, civic-minded citizens and educators, have a responsibility in completing the transition from the closed school to the community school, in a gradual, healthy and wholesome manner.

BULLETIN REVIEWS

CIRCULAR 201

Peach and Cherry Costs in Michigan

Wright, K. T., and Johnston, S.

Results are presented of a survey made in 1943, showing production costs on typical Michigan farms, in terms of man, truck and tractor hours, of materials used and of overhead charges. (15 pp., 9 tables, 7 figs.)

CIRCULAR 202

Apple and Pear Costs in Michigan

Wright, K. T., and Toenjes, W.

Results are presented of a survey made in 1943, showing production costs on typical Michigan farms, in terms of man, truck and tractor hours, of materials used and of overhead charges. (14 pp., 9 tables, 6 figs.)

CIRCULAR 203

Small Fruit Costs in Michigan

Wright, K. T., and Johnston, S.

Results are presented of a survey made in 1943, showing production costs on typical Michigan farms, in terms of man, truck and tractor hours, of materials used and of overhead charges. (13 pp., 10 tables, 4 figs.)

SPECIAL 337

Michigan Farm Organization and Practices in Type of Farming Area 14

Brown, L. H.

A description of the main farm enterprises of the area, their integration into a system of farm management and a discussion of factors responsible for success or failure. (35 pp., 6 tables, 2 figs.)

JOURNAL ARTICLE ABSTRACTS

The Relation Between Number of Ears Opened and the Amount of Grain Taken by Redwings in Cornfields

HAYNE, D. W.

Jour. Agr. Res. 72 (8): 289-295. 1946. [*Journal Article 715 (n. s.) from the Michigan Agricultural Experiment Station*]

Damage to corn by flocks of the eastern redwing [*Agelaius phoeniceus phoeniceus (L)*] occurs in local areas over a large part of the United States. The pattern of damage in a cornfield at any particular moment is the expression of certain feeding habits of birds in flocks. This paper presents the results of an attempt to describe the progressive increase of damage in algebraic terms and to test the validity of the equations developed by application to data gathered in damaged fields.

The relationship between the proportion of the ears of corn in a field opened and the proportion of the grain taken is found to be fairly close, but not linear. This relationship is here described by the equation:

$$y = -2.30\ b \log (1-X)$$

where y is the proportion of the grain removed, b is the proportion of the grain in a single ear removed by a bird in one visit, and X is the proportion of the ears in the field which are attacked.

The curve of this equation is fitted to the field data, from 198 damaged cornfields. There seems to be no necessity for assuming that birds return to an ear of corn which has once been opened, merely because the ear has been opened.

Sodium as a Crop Nutrient

HARMER, P. M., AND BENNE, E. J.

Soil Science, 60 (2): 137-148. 1945. [*Journal Article 762 (n. s.) from the Michigan Agricultural Experiment Station*]

Applications of sodium salts were made to a large number of crops. Many showed little response to applications. Another group showed a distinct response in the form of increased growth, greater resistance

to disease and to drouth. In those instances in which the crops were benefitted the sodium appeared to be more valuable in the presence of ample potash than in its absence. There was little evidence of its ability to take over any of the functions of potash where that element was deficient.

The Efficacy of the Microscopic Examination of the Incubated Producer Milk Samples in Detecting Streptococcic Mastitis in Dairy Herds

JOHNSON, H. P., AND BRYAN, C. S.

Jour. Milk Tech., 9 (4): 197-202. 1946. [*Journal Article 789 (n. s.) from the Michigan Agricultural Experiment Station*]

A total of 863 cows in 83 herds were checked for the presence of streptococcic mastitis by the collection and examination of individual cow samples of milk. Of these 78.3 percent of the herds and 21.9 percent of the cows were found to be infected.

Producer samples of milk were collected on the same day from each of these dairy herds and examined microscopically, following incubation, for the presence of long chain streptococci. An analysis of the data indicates that:

1. In 60 herds a positive producer sample indicated accurately the presence of streptococcic mastitis, as verified by the examination of individual cow samples from each herd.

2. In four herds positive producer sample results were not verified on examination of cow samples. Since these producer samples were taken out of the weigh tank, the possibility of contamination from a previous infected sample is suggested. To overcome this source of contamination, producer samples should be collected directly from the cans.

3. In five herds a negative producer sample result was not confirmed upon examination of the individual cow samples because in four herds one infected cow was found and in the fifth herd two were located. No explanation is offered for these results.

4. In the remaining 14 herds the negative producer sample results accurately indicated the freedom of the herd from streptococcic mastitis as confirmed by the results of individual cow testing.

Heat Resistant Bacteria from an Unclean Milking Machine Invade the Udder of the Cow

BRYAN, C. S., BRYAN, H. S., AND MASON, KARL

Milk Plant Monthly, 35 (8): 30-32. 1946. [*Journal Article 817 (n. s.) from the Michigan Agricultural Experiment Station*]

The properly pasteurized milk from a small dairy increased in bacteria count during a 4-month period from its normal level of 15,000 to as high as 2,500,000 on some days. Despite careful plant cleaning and sanitizing the high count continued until the source was located and eliminated. The immediate source of the high count of heat resistant bacteria was the milk of one of the seven producers. Here an unclean milking machine contributed heat-resistant bacteria to the milk both directly and during the milking process and indirectly by having served to inoculate the cow's udders with these bacteria. The cows rid themselves of the heat-resistant bacteria in periods varying from 1 to 4 months after the milk equipment was properly cleaned and sanitized. During this same period the standard plate bacteria count of the properly pasteurized milk of this dairy decreased to its previously normal level of 10,000 to 25,000.

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